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THE MAPLE SUGAR INDUSTRY OF VERMONT.

THESE are the days when the maple sugar makers are furbishing up their big brass pans, collecting sap spouts and looking after the well being of the sap buckets. In a very few weeks the spring sun will have sufficient power to influence the running of the sap, and begin the first stage of a season's industry in the sugar camps east and west. The middle-aged New Englander can recall that in his boyhood his section of the country led all the rest in the production of maple sugar, the honors falling to Vermont. To-day the Middle West takes precedence, in quantity if not in quality.

Up to a few years ago the annual output of Vermont was 15,000,000 pounds of maple sugar, but within the last few seasons that average has fallen, until this year it will not be much more than two-thirds the quantity named. The next largest producer is Ohio, and that State has marketed each year an average of 12,000,000 pounds. Northern New York produces a large quantity of maple sugar, and the amount is annually increasing. Other States along our northern border produce more or less maple sugar, but the quantity is comparatively insignificant when the aggregate output of the States named is considered. The hill country of Maryland and the Virginias is a maple sugar country that is opening up to a moderate extent and promises to increase in importance, as the maple sugar makers gather wisdom, for there the industry is in its infancy.

GATHERING THE SAP.

In making maple sugar the trees are first tapped or bored into about an inch and a half, at a convenient distance from the ground. A spout is then driven into the tree, and a bucket hung below the spout. A quarter of a century ago every maple sugar maker manufactured his own spouts. It furnished employment for the jack-knife brigade on winter evenings, and resulted in the production of thoroughly practical, if not always ornamental creations. Everything was home made, except the big brass kettle in which the sap was boiled. Nowadays, the sap spout is purchased and is as thoroughly a patent affair as the churn or the windmill.

Time has not changed the tricks of the sugar maker so far as tapping his trees on the weather side is concerned, in order to secure the largest run of sap. For instance, he always taps his trees on the south side, except toward the close of the season, when he changes his method because the sun lingers longest on the north side. After the tapping and placing of the buckets is complete, there is a cessation of orchard work. It is a slow process, but a sure one, and after a time there is sufficient in the various buckets to make it worth while to begin collecting.

MAKING MAPLE SUGAR—BOILING THE SAP.

Years ago when this stage of the proceedings arrived, the collector and his helper shouldered "trees," or "yokes," as they are now called, which were adjusted to the shoulders. Dependent from each end of the yoke was a rope with a hook attached, on which swung a pail. The sap collector would go from tree to tree and pour the accumulated sap in each bucket into the pails he carried, being careful to see that the amount in each pail was equal, in order that none might be spilled. This was kept up until the shoulder buckets were full and then the sap was taken to the sugar house, if there was one; if not, to the cellar where it would keep cool, and here permitted to await the time for boiling.

The boiling place has undergone a radical change in the last ten years. From the old iron kettle hung on a pole resting on two forked sticks driven into the ground, it was a comparatively easy transition to the big open pan set over a large brick arch in a rude house. Now, there are the quick-acting evaporators, closely covered and carefully watched to prevent the least scorching and to keep out any dirt. The sap is boiled in these evaporators to a sirup weighing about ten pounds to the gallon. The bulk of the sugar made is sold this way, and very few more welcome dainties are provided for epicures. The remaining sugar is boiled still more until it granulates, and is poured into buckets and pails. Then it is ready for market, for the wholesaler, and soon afterward begins its journey into the world.

ARSENIC IN BEER.—The commission of experts, consisting of Sir Lauder Brunton, Dr. Thomas Stevenson, Dr. A. P. Luff, Mr. A. Gordon Salamon, Mr. Samuel Buckley, and Mr. J. Fletcher Moulton, Q. C., M.P., appointed by the Manchester Brewers' Central Association, have presented a report to the Association. The commission have thought it necessary to investigate, and determine what is the most suitable method of testing beers for arsenic, and recommend the Reinsch test in preference to all others at present known, because their investigations have satisfied them that it is the best and most reliable test for arsenic in beer. The mode of performing it is as follows:

Take 200 c.c. of the beer in a porcelain evaporating dish. Raise the liquid to the boiling point, and then add 30 c.c. of pure concentrated

hydrochloric acid. Insert a piece of pure bright copper foil, about one-quarter inch by one-half inch in size, and keep the solution gently boiling for forty-five minutes. If at the end of that time the copper remains bright and red, the beer is free from arsenic.

If a deposit is obtained on the copper, the foil is to be washed successively with water, alcohol and ether (care being taken that these are pure), dried at a temperature not exceeding 100 degrees C., and subjected to slow sublimation in a thin reduction tube of small section, and not less than two inches long, the upper portion of which should be warmed before the sublimation begins. For the purpose of the sublimation a small spirit-lamp flame should be used. If any sublimate is obtained, it must be examined under a magnifying power of about 200 diameters. Any sublimate which does not show well-defined octahedral or tetrahedral crystals is not to be considered arsenical.

N.B.—It must be borne in mind that the blackening of the copper or a deposit thereon from the preliminary operation does not demonstrate the presence of arsenic in beer. Abundant blackening and deposit may be obtained from the purest beer.—Chem. and Drug.

[Concluded from SUPPLEMENT, No. 1313, page 21050.]

THE OPTICS OF TRICHROMATIC PHOTOGRAPHY.*

III.

ATTENTION is here called to the fact that in this device the reflecting surfaces were inclined to the optical axis in the perpendicular plane; and there is no publication of the idea of inclining them in the horizontal plane previous to 1894. Charles Cros, in a communication to the Photographic Society of France, in 1879 (The Review of Games, Arts, and Sports, February 15, p. 221), in describing a transparent mirror device, expressly states that the mirrors are inclined at 45 deg. to the *sides* of the box. Neither this nor any other persistence of vision device for this purpose has ever come into practical use.

The next conception of a photo-chromoscopic device was my own, for which I applied for a patent in February, 1892.[1] In this device, the two transparent and one silvered reflector are supplemented by additional silvered reflectors disposed in parallel planes, in such manner as to dispose all the images on one plane, and the doubling of outlines was avoided by employing slightly wedged clear glass reflectors. This instrument could not well be made stereoscopic, and although perfect in its performance as a monocular photo-chromoscope, it was too costly and delicate in its adjustment for commercial manufacture.

In March, 1894,[2] C. Nachet, of Paris, patented a device in which two of the images were blended to the right eye by the aid of a thinly silvered or platinized mirror, and the third image, made from a different view point, was seen directly with the other eye. This was an attempt to make a combined photo-chromoscope and stereoscope, but, owing partly to the fact that very few people (if any) can successfully "blend" two primaries through two eyes, it was soon abandoned. This idea, first published by M. Nachet, is fully set forth in the mémoire attributed to Louis Ducos du Hauron as of the date July 14, 1862, but first published in 1897; nevertheless, it is credited to Nachet on page 360 of the same book in which it first appears as belonging to Louis Ducos du Hauron in 1862.

In September, 1894, Carl Zink, of Gotha, published a description of a photo-chromoscope having three rectangular "steps," and two transparent and one ordinary silvered mirror, and a "cosmorama" lens. The new features in this device were the horizontal disposition of the steps, inclination of the mirrors in the horizontal plane, and all disposed to reflect from their upper surfaces, and an adjustment of angle to secure the best direct illumination of the reflected images. A horizontal disposition of the three mirrors had never been published, although it appears in the Du Hauron 1862 mémoire already referred to, with one of them disposed to take the reflection from the under side. Zink's publication was anticipated by my application for a patent upon the same and several other important improvements in the "step" photo-chromoscope with transparent mirrors. My patent application, dating July 3, 1894,[3] discloses on only the arrangement shown by Zink; but (1) an efficient contraction to two steps instead of three, whereby the apparent area of the picture is nearly doubled, (2) the use of colored glass reflectors by which doubling of outlines is avoided without the use of convex lenses or "thin silvering,"[4] and the construction and adjustment proportionately simplified, (3) a stereoscopic construction, whereby the illusion of reality is brought to perfection, (4) a modification by which the images are disposed in line upon a single plate.

None of these ideas had been published before my dates of record.

Some months after the publication of my patent, Nachet claimed the same construction on the strength of a clause in his patent which was to the effect that two transparent mirrors instead of one could be used in his three-image stereo-chromoscope. The natural inference from the wording of this clause was that he meant one in front of each eye, the construction since adopted in the "Kromaz," and not an arrangement involving a totally different idea like my own. Even if it is assumed that he may have meant that two transparent mirrors could be used in front of one or both eyes, the fact that he so disposed his transparent mirror as to reflect from *below* proves conclusively that he had no thought of direct lighting of the reflected images and the use of a folding chromogram, which I patented and which he reproduced, along with other details shown in my patent drawings, such as a tray base and strut for fixing the inclination, months after the publication of the patent.

Inclination of the mirrors in a horizontal plane, with the reflections taken from the upper surfaces, and the three images disposed in line upon one plate, patented and first published by me, also appears in Du Hauron's Melano-chromoscope.

As before stated, inclination of the mirrors in a horizontal plane, *but at opposite angles*, is disclosed in the Du Hauron 1862 mémoire. It is remarkable that the three-image stereoscopic construction patented by Nachet in 1894, a stereoscopic construction with three pairs of images, a two-step construction, methods of stereoscopic projection, and other ideas first made public by others, appear in this mémoire, and are first published as Louis Ducos du Hauron's inventions twenty-eight years after he was challenged by Charles Cros to show a record antedating Cros' sealed mémoire of 1867. Du Hauron's reply to this challenge appeared in Cosmos, July 24, 1869, when he said, "I myself could have, at the conception of my idea [which he then dates back '*five or six*' years] consigned its generalities to a sealed letter. . . . I gave up to the higher ambition to give to society and to France a system of heliochromy sufficiently elaborated," etc. This is his reply in 1869, *seven* years after it is now stated that he had prepared expressly for presentation to the Institute of France a mémoire of nearly 3,000 words, describing a remarkably elaborate system, and that this mémoire was duly acknowledged and commented upon by M. Lélut, and read by at least one other member of the Institute, preserved all this time, and even now referred to as a "publication" in 1862. Although it may be inferred that his failure to get his mémoire presented to the Institute decided him to try to reduce the method to successful practice before trying again, it would seem most natural that he should have produced such conclusive proof of priority in reply to Cros if he was able to do so.

It is quite probable that the inconsistencies which I have noted may be satisfactorily explained away, but it seems proper, under all the circumstances, to raise the question, and I hasten to say that, for reasons well known to many, this can be done without questioning the integrity of Louis Ducos du Hauron. I don't think the question would have been raised in my own mind if I had not already regularly found my own published ideas reappearing in France as French inventions, dated back without evidence, and my own publications totally ignored.

My 1894 "two-step" photo-chromoscope (to which I have given the distinctive name of Kromskop) has never been rivaled by any other form of viewing device, and has been finally perfected by two "improvement" inventions.

As originally constructed, it was found that the inclination of the transparent reflectors between the eye and the green image introduced such a distortion of that image that the red and blue images, reflected from plane surfaces, could not be perfectly superposed upon it. The reason for this can be readily shown by tracing the path of the rays from the top and bottom of the green picture to the eye, both direct and as changed by refraction through the inclined transparent mirrors, the amount of distortion depending upon the thickness of the glasses; but I need not take up time with such a demonstration here. Suffice it to say, that I soon found two ways of correcting this defect, both of which were rather unsatisfactory from the manufacturer's point of view. One was to employ slightly wedged reflectors, so disposed as to correct the distortion, and the other was to introduce a similar distortion in the reflected images by attaching springs to the reflectors, so as to make the reflecting surface slightly cylindrical.[5] The first method, although efficient, called for weakly-prismatic glasses, which cannot be obtained of sufficiently uniform accuracy by commercially practicable methods of grinding and polishing. The second method, although quite practicable in a commercial manufacture, is less perfect, and somewhat clumsy and troublesome. The final solution of the problem, a most obvious one when you come to think about it, was the introduction of a plane glass under the red image, equal in thickness to the sum of the two transparent mirrors, and inclined at the same angle.[6] This leaves the blue image uncorrected, but the error is only one-half what it would be in the red, and is of far less critical importance in the result, so that the image is now satisfactory to the eye. A kromskop made up without this compensation would now be instantly condemned.

Another defect which troubled me for a long time grew out of the fact that the colored glass reflectors have polarizing properties, while the silver mirror which illuminated the green image did not have this property. With a gray sky as a source of illumination this did not much matter, but with a polarized blue sky the amount of light reflected by the transparent mirrors of the red and blue images varied with the angle of polarization, so that an instrument which gave a bluish-white field when pointed to a portion of the sky near to the position of the sun, would give a yellowish-green field when pointed in a different direction, toward a part of the sky which appeared still bluer to the eye. The amount of light reflected from the silvered mirror was the same for all positions, but the amount reflected by the transparent mirrors sometimes varied enormously. There are half a dozen ways in which this defect can be lessened, but it is now eliminated by substituting a bundle of glasses for the silvered reflector in front of the green image.

The fields of the kromskop also became green by reason of the light gradually darkening the red screen, and this defect has been remedied by employing a different coloring material.

With these and other detail improvements, the performance of the kromskop is perfect, and, although the public is slow to appreciate its value and importance, it is coming into use in the United States in the fields of entertainment, art, medicine, and commerce, and will probably be regarded as a necessity for many purposes in course of time, as it is the only means of producing perfect visual reproductions of thousands of objects.

Another form of the instrument, which I call the "miniature" kromskop,[7] is a modification of one of the plans of construction which I showed in the original patent, permitting of disposing the three images in a line upon a single plate. To simplify the construction, images of the kromogram are looked at obliquely, and the consequent distortion corrected by introducing a prismatic lens and a 7 deg. prism. This construction is practically very much cheaper than anything else that has been proposed, and the images, although small, appear larger than in the far more costly melano-chromoscope, which Du Hauron has produced by grafting some of the same ideas upon his original conception. Probably, I should say, which Alcide Ducos du Hauron has produced by grafting some of my ideas upon his brother Louis Ducos du Hauron's original conception.

With the exception of the "miniature" kromskop, all forms of photo-chromoscope can be adapted for making the photographic color records; but not one of them is a desirable construction for a camera, and no one who knows all the requirements will waste his time trying to make them interchangeable. Even if the general plan was suitable for both purposes, it would be both better and cheaper to construct two instruments, one specially adapted for each purpose, than to provide all the substitutions and readjustments necessary to make a single one efficiently interchangeable. This conclusion has been forced upon me after making several interchangeable instruments myself, and examining those which have been made by others.

Moreover, the most efficient viewing instrument is the kromskop, with images in three planes, and no camera for making kromskop pictures will ever prove permanently satisfactory unless the three images are produced upon a single plate. I am so sure of this that I would feel justified in ignoring all three plate cameras, but for the fact that the construction of some of them involves ideas which also enter into the one-plate cameras, and have had a part in their evolution.

The idea of employing as a camera an instrument essentially like the kromskop, with dark slides attached, is a favorite one with many; but, besides the objections to trying to make such an instrument efficiently and conveniently interchangeable, and the objection to trying to use three separate sensitive plates, it has some very serious optical defects as a camera. In the first place, the illumination of the images will be uneven, because the amount of light reflected from a transparent mirror varies with the angle of incidence, which differs for different parts of the cone from the objective, and the illumination of the images formed by rays reflected from the transparent mirrors is greatest just where it is weakest in the image formed by transmitted rays, or by reflection from a succeeding silvered mirror. In the second place, the proportionate illumination of the three images necessary to make the exposure required equal for the three plates cannot be readily controlled except by the use of compensating screens at the objective, which are almost certain to upset the selective absorption, especially if in the form of a party-colored adjustable diaphragm aperture.

In the third place, the polarizing properties of the transparent mirrors will under some circumstances introduce serious errors in the color record. This is an important matter, of which I shall speak again. Here are five counts against trying to make an efficient camera out of an efficient photo-chromoscope.

Louis Ducos du Hauron divorced cameras and viewing instruments at an early date.[8] He originated the method of controlling the relative degree of illumination of the three images by employing three objectives and three separately adjustable diaphragms, a principle which I once thought belonged to me; but he does not appear to have recognized the necessity of correction for unevenness of illumination across the images, which I accomplished by inclination of the diaphragms in the optic axis. This may appear to be a small matter, but the absence of such correction really constitutes a fatal defect.

The next step was to dispose the three images upon one plate, and this I did in 1892,[9] in trefoil, and in 1895,[10] in a line. In 1899,[11] I devised two new and simpler transparent mirror cameras disposing the images on a line. Hundreds of successful negatives have been made with the 1895 cameras; the 1899 cameras, although equally efficient and of much simpler construction, will probably never come into use because already superseded by a still simpler camera of a different type, which I have since devised, and which, at least as a view camera, can have no rival.

Now, with respect to the defect introduced into triple cameras by the polarizing properties of transparent mirrors of glass, a defect which nobody else has yet noted. Suppose that we have a camera with two transparent and one silvered mirror inclined in parallel planes one behind another in the optic axis, and that we are photographing a landscape view in which there is a portion of polarized sky. Naturally, the red image will be formed by reflection from the silvered mirror, and the blue and green images by reflection from the transparent mirrors. If the sky polarization is at such an angle as to oppose free reflection from the transparent mirrors, the sky will be underexposed in the blue and green images relatively to the other parts of the view, but will be fully exposed in the red image; in the reproduction the colors will be quite incorrect. The same will be true if the red image is made by light directly transmitted to the plate through the transparent reflectors. Other complications will arise if one of the transparent mirrors is inclined in a perpendicular plane, and the other in a horizontal plane. In either case, every colored surface which has polarizing properties may be expected to be falsely rendered.

There is a remedy for this defect, so far as it ap-

* The Third Traill Taylor Memorial Lecture. By F. E. Ives. Read before the Photographic Society of Great Britain.—From Br. Jour. of Photography.

[1] United States patent No. 475,084, published May 12, 1892.

[2] French patent No. 237,394, March 29, 1894.

[3] United States patent No. 531,040, published December 18, 1894.

[4] The possibility of employing colored glass reflectors was first disclosed in my United States patent No. 475,084, published May 17, 1892; but the particular relation of the colors of the glasses to the respective images was first published in The Journal of the Society of Arts, May 19, 1893, p. 666, and patented in the United States in 1894. In his treatise published in 1897, Alcide Ducos du Hauron publishes this for the first time as a proposition of his own; and it is only one of the many ideas which have been claimed by Du Hauron only after they had been published or patented by others. Even Clerk-Maxwell and Harry Collen are totally ignored in this book.

[5] United States patent No. 622,480, published April 4, 1899.

[6] United States patent No. 635,253, published October 17, 1899.

[7] Journal of the Photographic Society of Philadelphia, March, 1900.

[8] British patent No. 2,973, July 22, 1876.

[9] United States patent No. 475,084, published May 17, 1892.

[10] United States patent No. 564,889, published September 24, 1895.

[11] United States patent No. 655,712, August 14, 1900, and another, not yet published.

plies to polarized skies. By placing a quarter-wave mica film in front of the camera aperture the light may be circularly polarized before reaching the transparent reflectors, and it is then reflected like unpolarized light. The mica film should be in a revolving mount, in order to set it always with the axis at 45 deg. to the plane of the incident polarized ray.

It is true that the setting of the quarter-wave film, which is correct for the sky, may be quite wrong for other polarizing objects which appear in the view. Water and even foliage give polarized reflections, and kromskop landscape reproductions have often been criticised for defects due solely to the polarizing properties of the transparent mirrors in the camera.

Transparent mirror cameras possess one special merit, which is that, when properly constructed, they give, with one exposure, absolutely identical view points for the three images. This would be very important indeed when utilizing large apertures or photographing very near objects; but no constructions, so far mentioned, of transparent-mirror single-plate cameras permit of the employment of a large aperture, and they all require a good deal of knowledge and skill to properly construct and adjust.

Recently I have devised a one-plate transparent-mirror camera which can be made to fulfill all theoretical requirements with apertures as high as *f*-8, but its construction involves the employment of two large and very costly blocks of optical glass, and the angle of view is small, so that I still prefer for general studio work successive or alternating exposure cameras, one type of which I patented some years ago in England.[12]

We now come to the newest view camera; but, as leading toward it, I must go back to a suggestion made by Mr. Dallmeyer in 1891,[13] and which had the merit of great simplicity together with the defect of separate view points. I refer to the use of rectangular prisms for dividing the light into three image-forming portions at the diaphragm aperture of the lens. This was a three-plate camera, and the use of rectangular prisms necessitated three separated diaphragm apertures in order to secure equality of illumination across the plates, the amount of separation of the diaphragm apertures depending upon focus of lens and angle of view. I used a similar arrangement myself in 1888, and a one-plate camera with triple aperture in 1890, but, although I published the fact in 1888 that I had a camera which made the three negatives simultaneously from "very nearly the same point of view," I cannot find that I published the construction.

In 1889,[14] I modified this construction by substituting equilateral prisms for rectangular prisms, and thus obtained what may be described as a single, narrow, party-colored aperture, giving practically a single view point, and yet transmitting enough light to make kromskop pictures of landscapes with five-second exposures. Finally, by employing rhomboidal prisms, I projected all the images backward upon a single plate, and, taking advantage of the property of the higher refractive index of glass as compared with air to extend the focal point, so calculated the form and size of the prisms as to make the images identical in size and perspective upon one plane.[15] This camera, which, notwithstanding its small aperture, is as quick as any of the efficient transparent-mirror cameras, except the new one last mentioned is incomparably simpler and easier to construct and adjust than any other efficient one-plate triple camera ever devised, and is entirely free from the polarization defect.

This form of camera can be made stereoscopic, and it can also be adapted to work with a comparatively large aperture and single view point for studio work by mounting the rhomboidal prisms on a rectilinearly vibrating support, so that the light is transmitted to the different images alternately in rapid succession. The movement of the prisms does not disturb the position or definition of the images, so no shutter is required, and the exposure is always going on in such a way as to make one as independent of fluctuations in the light as with the smaller-apertured view camera. All other alternating exposure cameras which have been devised require a shutter to cover the lens aperture during the movements, involving considerable loss of time in making the exposures. There are so many obvious ways of carrying out the idea with this limitation that they are not worth mentioning.

I have now come to the end of the list of triple cameras which seem to me to contain original features of practical value. The sliding back for making successive exposures upon a single plate still has the advantage of being much cheaper than anything else, and is efficient in a steady light with still objects. I make this in stereoscopic form with inverting prisms in front of the objectives, so that the stereoscopic pairs are reversed and transposed ready for mounting for correct vision in the stereoscopic kromskop.

I believe the first special triple lantern for color projection was used by me in my demonstration at the Franklin Institute in February, 1888. On a single lantern body there were three complete optical systems, disposed side by side, with the objectives adjustable for register, and three lime lights. The three positives were mounted on a single wooden slide.[16] This lantern was made to fold very compactly, according to a principle which I patented in 1885,[17] and was adapted for ordinary dissolving views as well as color projections.

In 1891, Albert Scott devised a quadruple projection apparatus with one source of light, one condenser to parallelize the rays, and four smaller condensers and four objectives to project the four images, which were of very small size. It is obvious that a triple-image apparatus can be made upon the same principle.

At the annual meeting of the American Association for the Advancement of Science, at Springfield, in 1895, I employed a "lantern kromskop," which was substituted for the ordinary lantern front in order to make trichromatic projections. In this device a small condenser parallelized the rays from an electric arc, and the light was divided into three portions by an arrangement of bundles of clear glass and silvered mirrors, after which it passed in parallel beams to three separate condensers, color screens, and positives, coming into three objectives, adjustable for register. In front of these objectives, 15 deg. prisms were used to separate the images in trefoil, and bring them back into register again for demonstration purposes.

An improvement upon this device is shown in my British patent, No. 5,800, of 1897, in which swinging lens fronts, coupled to pivoted silvered reflectors and operated by a lever, are substituted for the revolving prisms for separating the images upon the screen. I have also recently improved the construction and adjustments of this instrument.

It is obvious that, by adapting three condensers and three sources of light to any photo-chromoscopic apparatus, projections can be made, and this idea has been patented more than once; but it is far too wasteful of light to be worthy of consideration from a practical point of view. A single source of light is as efficient with the "lantern kromskop" as three sources of light can possibly be with any transparent-mirror direct-viewing device, for reasons which should be obvious to anybody who knows enough of optics to trace the reflections in both instruments.

Having described the most successful and important methods of positive synthesis with three images, I now come to the idea of analysis and positive synthesis with a single image, which may be a sort of linear mosaic of the three separate images heretofore considered.

This idea belongs to Louis Ducos du Hauron, and is a brilliant conception, although of doubtful, or at least very limited, practical importance. As a clever invention it ranks as high as anything that has been done in trichromatic photography.

The principle of this method was fully set forth in Du Hauron's 1868 patent, coupled, however, with his failure to recognize the correct triad of primaries, and the principle of color-curve analysis, and pure-color synthesis. He proposed to make a single negative image through a screen made up of fine juxtaposed colored lines, alternately red, yellow, and blue, and then to view a positive from this negative through the same screen, making the red lines of the screen cover the lines which were made in the negative through red lines, and so on. It is evident that, with lines fine enough not to be separately perceived by the eye, the result should be a complete colored picture requiring no special viewing device to see it in its perfection.

Years after I had demonstrated the principle of color-curve analysis and pure-color synthesis, Dr. Joly applied the principle to this process, until then unknown to me. McDonough, in America, also revived the process, with red, green, and blue-violet colors, but not with a full recognition of the true principles of color selection.

This process is exceedingly difficult to carry out successfully with colored lines fine enough not to be offensive to the eye, and, when the images are made stereoscopic and magnified in the stereoscope, the line structure is positively distressing. It is best adapted to effect for large window transparencies, to be seen from such a distance that the colored lines are not separately perceived; but it is said that when so exposed the colors fade considerably in a little while.

It is very difficult, if not practically impossible, to make a correct *selective* line screen with from 300 to 600 lines to the inch—it is difficult enough to make such screens with superposed colored films and glasses in separate squares—and it is doubtful if there are any suitable dyes for this purpose which are permanent. Such records can, however, be made by successive exposures through an opaque line screen, employing the same selective color screens that are used in the kromskop cameras.[18]

In 1895, I thought of a method of making such negatives which permits of a single exposure for all three color lines, with an opaque line screen, but I had no use for it until last year, when I also devised a means of synthesis for such pictures without the colored line screen, and I then applied for patents for both inventions.[19] I afterward learned that Jan Szczepanik had applied for a patent for the camera in France, No. 287,709 of 1899, and that J. A. C. Branfil published a somewhat similar idea in The British Journal of Photography, February 26, 1897. It is really, however, an application to this process of my original principle (1886) of screen "pin-hole images" of the lens diaphragm in the half-tone process.

[12] British patent No. 3,232, 1897.

[13] The British Journal of Photography, July 10, 1891.

[14] United States patent No. 632,573, published September 5, 1899.

[15] Journal of the Photographic Society of Philadelphia, March, 1900, p. 21.

[16] United States patent No. 432,530, published July 22, 1890.

[17] United States patent No. 338,074, published March 16, 1886.

[18] United States patent (Macfarlane Anderson) No. 559,051, April 28, 1896, and United States patent (F. G. Harrison) No. 578,147, March 2, 1897.

[19] United States patent No. 648,784, published May 1, 1900, and another, not yet published.

REROLLED RAILS AS A MARKET FACTOR.

FIVE years ago experiments in rerolling rails were first begun, and four years ago a plant was erected for this purpose. It was supplemented by another in 1898 and another is contemplated. Since 1897 less than 100,000 tons of steel rails have been rerolled, but the capacity of the three plants will be about 400,000 tons per year, thus showing a large possible gain in the industry. The present consumption of steel rails in the United States is about 1,800,000 tons, of which about 800,000 tons are required for renewals. The present rerolling possibilities, therefore, affect about one-half that tonnage. The rerolled rails are said to be superior in wearing qualities to the new rails, because of the reworking and the reduced temperature at which the rails are rerolled. The present cost of rerolling is from $5 to $6 per ton. "A new and important element thus promises to be added to the trade in both old and new rails," says Iron and Steel. "The rerolling process will in time seriously affect the price of the new rails and also that of the rails that have outlived their usefulness, and in turn the price of rails, both old and new, will make or mar the possibilities of the rail renewers. When conditions were so abnormal as they were in 1899, railroad companies selling their old rails at a higher price than they were paying for new ones, there was little, if any, incentive to reroll rails, but allow the spread between the price of old and new to get far beyond $6 and the subject is one to be received with open and friendly arms by the common carriers. It will be observed that this spread in price is affected alike by the values of old and new rails. A rise or decline of the one is just as material as a rise or decline of the other. The degree to which rail rerolling becomes popular will depend, in short, upon market conditions. As the iron and steel markets broaden and deepen, they become more complicated. An important cog in the machinery that moves the metal world will be that now shaping in potential strength at the rail rerolling mills in the country."

FROGS FOR MARKET.

A BIG HATCHERY TO BE ESTABLISHED IN MASSACHUSETTS.

FROG cultivation is the latest industry to attract the attention of Boston capitalists, says The Boston Transcript. A farm in Ware has been purchased for the purpose, and the growth of frogs will be undertaken this spring on a scale which has never been attempted in this country.

The principal promoters are Charles L. Flint and E. R. Flint, of Boston; George Fernald, of Portland, Me., and Frederick A. Merrill, of Ware. They have recently organized the Massachusetts Frog Company under the laws of Maine. A farm of ten acres on the outskirts of Ware was purchased from Daniel S. Kennedy, and is now being equipped for the undertaking. The land is on the border of Harwick Pond, and was a part of the old King estate.

The tract is admirably suited to its requirements. A running stream passes through it, furnishing an adequate supply of water. The system of cultivation will be by means of a series of artificial ponds. These are now in process of construction. They will be of various sizes, and will be connected by a series of locks. They will be fitted with walls and bottoms of cement. The smallest of the series will be about 10 feet by 3 feet in size. In these the eggs will be hatched, and as the creatures develop they will be transferred into larger ponds. When they are a year old they will occupy bodies of water about 10 feet square, and during the second year will be transferred to ponds 30 feet square. When two years old the frog is full grown, and will be ready for the market.

It is expected that an ample supply of eggs for stocking the hatchery will be found in the ponds of neighboring towns, and as the eggs germinate easily, no trouble is anticipated in the propagation. The young animal feeds on a substance found on the surface of the eggs, so that no food will have to be supplied during the early growth. When the creature reaches the tadpole stage a quantity of crustacea will be supplied. The lower forms of animal life will be procured, like the frogs' eggs, from neighboring ponds, and, as they propagate rapidly, will soon furnish an incessant supply of food in the artificial ponds. The cultivation is a matter of small expense and trouble, and yet the returns yielded will be very large for the amount invested. Arrangements are being made for the growth of from twenty thousand to forty thousand frogs a year, and the facilities can be increased so that an output of one hundred thousand can be made, if the demand warrants. After the ponds are stocked, there would be only a slight increase of labor required to effect the growth of the larger number.

The principal market for the frogs will be found in colleges and medical schools. There is a growing demand for the creatures for use in the study of natural history, and especially for purposes of medical research. At present the supply is insufficient, and students, especially in winter, find it difficult to procure any specimens. The cultivation of the frog has hitherto been promulgated only on a small scale, and chiefly as food. Schools have been obliged to send to North and South Carolina for their specimens, and then have not been able to procure the animals in the best condition. The farm at Ware will be equipped with heating apparatus, so that the supply will be constant and students will be enabled to obtain the objects of their experiments during the winter, when they are most desired for study. During the cold weather the frogs remain dormant in the mud. Large cakes of this soil will be dug from the ponds and removed to the heaters, where the frogs will be thawed out and sent to the schools in a normal condition, so that the blood circulation and the heart beat may be studied under the best conditions possible.

Hotels and markets will also be supplied. The building to be used as headquarters on the estate is now about half built, and will be ready for occupancy in the spring. The plant will then begin operations, and it is expected that the supply for hotels will be ready soon after the frost is out of the ground. The company will not be ready to furnish specimens for schools until some time later.

RHODESIAN WHITE ANTS.

AN interesting description of the ravages of white ants, or termites, in Rhodesia, is furnished by the Rev. A. Lebœuf to The Zambesi Mission Record for January. The special interest of the contribution centers in the account of the damage done to property by white ants in Rhodesia, which seems to be even greater than in India. It is no uncommon thing, says the writer, for the colonist, on returning from his day's labor, to find the coat he left hanging on a nail of his cottage wall and the books on the table, absolutely destroyed by these tiny marauders. Nor is this all. "On awaking next morning," writes Mr. Lebœuf, "you are astonished to see in the dim light a cone-shaped object rising from the brick floor a short distance from your bed, with two holes on the top like the crater of a miniature volcano. Upon closer examination, you discover that the holes have just the size and shape of the inside of your boots, which you incautiously left on the brick floor the night before. They have given form and proportion to an ant heap, and nothing is left of them except the nails, eyelets, and, maybe, part of the heels. And as the same dismal story, with variations, has to be told about every other article of apparel and all perishable objects, it must be admitted that there are drawbacks to the lot of a settler in Rhodesia.

[Continued from Supplement, No. 1313, page 21041.]

DOCK EQUIPMENT FOR THE RAPID HANDLING OF COAL AND ORE ON THE GREAT AMERICAN LAKES.*

By Arthur C. Johnston, Member Civil Engineers' Club of Cleveland.

In Fig. 7 is shown the type of unloader built by the Brown Hoisting and Conveying Machine Company, the pioneers in the building of dock machinery on the lakes. It differs from the McMyler hoists, already described, in the type of towers employed and in the arrangement of the towers. The engines also have a single reduction gearing between the crank-shaft and drum, thus using a smaller engine with higher piston speed. The machines are generally arranged in groups of two, with the engines and boilers and operators in the rear tower. Both towers are generally moved along the dock by hand. There are over 175 bridges of the Brown type of conveyor at the different Lake Erie ports.

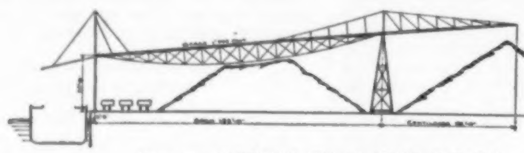


Fig. 7.—BROWN TYPE ORE HOIST.

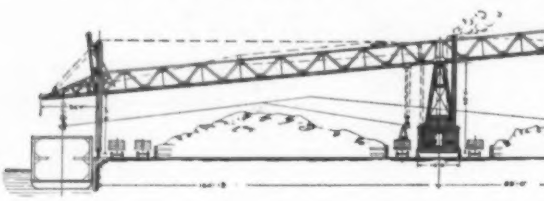


Fig. 8.

In Fig. 8 is shown yet another type of ore unloader, built by the King Bridge Company. Its distinctive feature is the great freedom of motion of the bucket. In both the Brown and the McMyler type the hanging block is locked in the wagon, and cannot be released without striking a stop which is bolted between the tracks. Thus, when unloading very narrow boats, the front stop on the apron must be moved in till it is vertically over the center of the hatch, and, similarly, for loading into a car on a track under the rear cantilever a stop must be placed over the center of the track to allow the bucket to be lowered in order to reduce the drop of the ore. In the King machines, however, the bucket can be raised or lowered to any desired height simultaneously with its travel along the bridge. The dock records of Conneaut Harbor show that nothing is lost in point of speed of operation, and, considering its advantages, it is surprising that the system has not been used to a much greater extent; its only disadvantage being that three drums and reversing engines are required for its operation.

When railway cars are always available "direct unloaders" are used to transfer the ore directly to cars. The latest plant of this kind is that shown in Figs. 9 and 10, built by the McMyler Manufacturing Company for the Pittsburg and Conneaut Dock Company, at Conneaut, Ohio. These machines have attracted a great deal of attention, and a description of their equipment will be of interest. Each machine, complete in itself, carries three bridges, which can be racked in and out to suit any spacing of hatches from 21 to 36 feet centers. The bridges cover five loading tracks, and are high enough to accommodate the largest lake vessels. An 80 horse power locomotive-type boiler supplies steam to three pairs of 10½ by 14-inch reversing engines. Each pair of engines has 40-inch drums for both hoisting and trolleying, mounted on the crank-shaft, the wagon having a three-part hoist. A feature of the arrangement of the engine is the method of controlling the clutch and brake for the trolleying drum, by using a steam cylinder, which, when it sets the brake, at the same time releases the clutch, and vice versa. Nine-sixteenths-inch cables are used for hoisting, running on 24-inch sheaves, except in the wagon, where they are 17-inch, and in the hanging block 15 inches in diameter. It is made impossible for a rope to leave the sheave by the use of the very simple guard shown in Fig. 11. The machines can travel along the dock by steam, and the racking of bridges is also effected by the engines. All movements other than hoisting and trolleying of the bucket are accomplished by means of a jack-shaft driven by a pinion on the crank-shaft of the main engines. Under actual working conditions the capacity of the plant of twelve bridges at Conneaut is 6,000 gross tons per day.

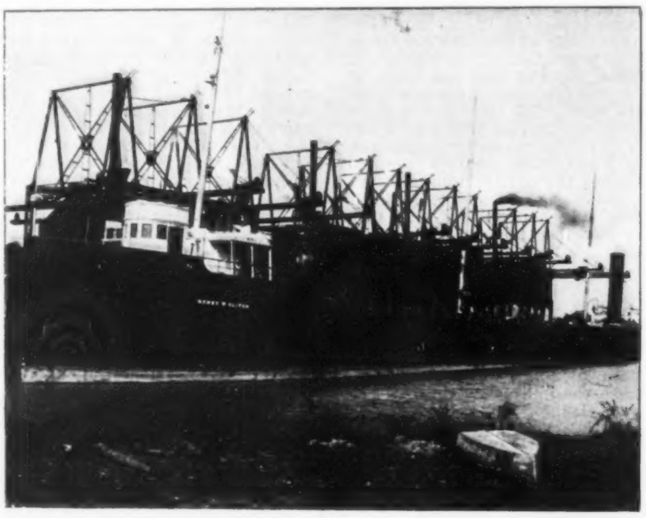


Fig. 9.—McMYLER DIRECT ORE UNLOADERS—PITTSBURG AND CONNEAUT DOCK COMPANY, CONNEAUT, OHIO.

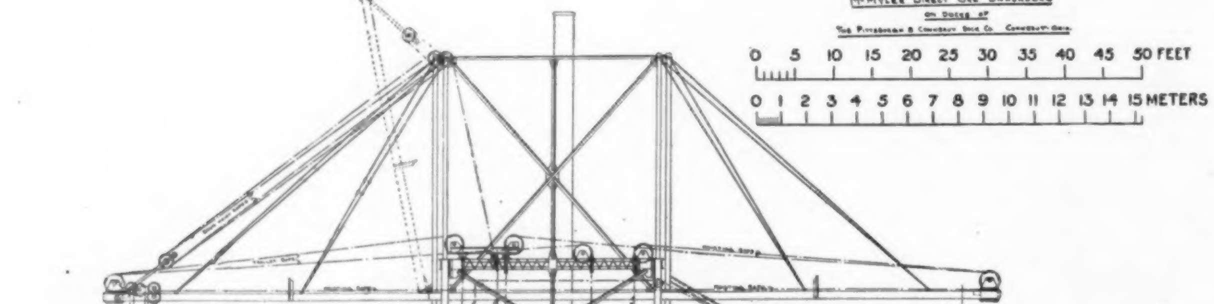


Fig. 10.

In a similar direct unloading plant built by the Brown Hoisting and Conveying Machine Company on the C. and P. docks at Cleveland the drum is geared to the crank-shaft, and the "suspended hook" is used. In neither the Brown nor the McMyler direct unloaders is the hanging block locked in the wagon, except to obtain the maximum clearance under the bucket. The lock on the wagon is very handy, however, to hang empty buckets from when the machine is idle.

With all these machines, in which the buckets are filled by hand, the actual cost of handling the buckets is very small, varying according to how nearly up to its full capacity a machine is worked; but under actual working conditions, from figures prepared by Mr. A. E. Brown, the cost per gross ton of ore handled by his machines varies from 0.7 cent to 1.37 cents. But the greatest expense is incurred in filling the buckets. The shovelmen are paid from 10½ cents to 13 cents per gross ton, so that, at an average rate of 11 cents per ton, it cost $1,980,000 for shoveling to unload the 18,000,000 tons of ore shipped this year. It was to reduce this cost that the Hulett ore unloader, shown in Figs. 12, 13, and 14, was designed and built by the Webster, Camp & Lane Machine Company for the Pittsburg and Conneaut Dock Company at Conneaut. Up to the present not enough has been done with this machine to obtain any data in regard to its performance. Its method of operation will be evident, however. The bucket is designed to lift 10 tons of ore at one scoop and dump it into the railway cars, or into a skip which can deliver it to the stock piles. All the motions on the trolley carrying the tilting girder are effected by hydraulic power, the pumps and tank being carried on the trolley itself, and the steam-loaded accumulator is used to partly balance the weight of the bucket. The operator is located just above the bucket, and descends into the hatch with it. The bucket can rotate in either direction about the axis of the vertical ram, thus enabling the ore lying in between hatches to be reached. It is expected that very little of the ore will have to be shoveled by hand with this machine.

The large vessels returning from the lower lake ports go up in water ballast or take a return cargo of coal; and to facilitate the loading of the enormous tonnage that is carried to the upper lake ports each year the car dumper has been developed—a machine which picks up bodily a car weighing 17½ tons and carrying 40 tons of coal and empties the contents into the hold of a vessel at the rate of as high as thirty cars per hour. Fig. 15 shows the first type of the McMyler "side dump" machine built on the lakes. The

* From the Journal of the Association of Engineering Societies.

first successful machines were of the "end dump" type, but they require special cars. They are still in operation, one at Ashtabula and one at Fairport. The machine shown in Fig. 15 is very flexible in operation, as the hinge of the aprons may be raised or lowered vertically to suit any class of vessel, and the car and cradle in ascending begin to turn over on striking the hinge point of the apron. This machine has been built with several types of chutes, but perhaps the most successful is the telescopic chute shown, as by its use much trimming of cargo is avoided. The car-clamping mechanism is beautifully simple, being merely four chains with counterweights suspended, the chains wrapping round the car as it is overturned. The cable is hoisted by four 1¼-inch cables arranged as a "two-part" hoist on 45-inch drums, driven through double reduction gearing by a pair of 14 by 18-inch engines. The load is lowered by using the engines as air pumps and throttling the exhaust, or with a foot brake, as desired. In operation, the machine, though so powerful, is extremely simple, considering the work it accomplishes, and has a record of thirty-two cars an hour; but, of course, this speed cannot be maintained on account of delays in switching cars and shifting the boat to reach different hatches. There are three machines of this type in

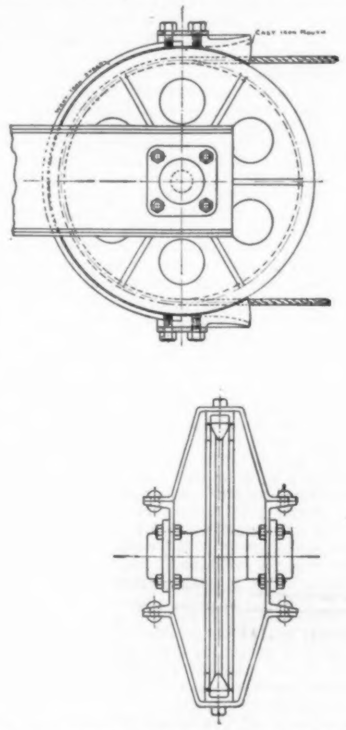


FIG. 11.—ROPE GUARD FOR SHEAVES.

operation: one on the docks of the Cuddy-Mullen Coal Company at Cleveland, one on the docks of the Cleveland Terminal and Valley Railway at Cleveland, and one at Erie, Pa., on the docks of the Erie and Pittsburg Railway.

(To be continued.)

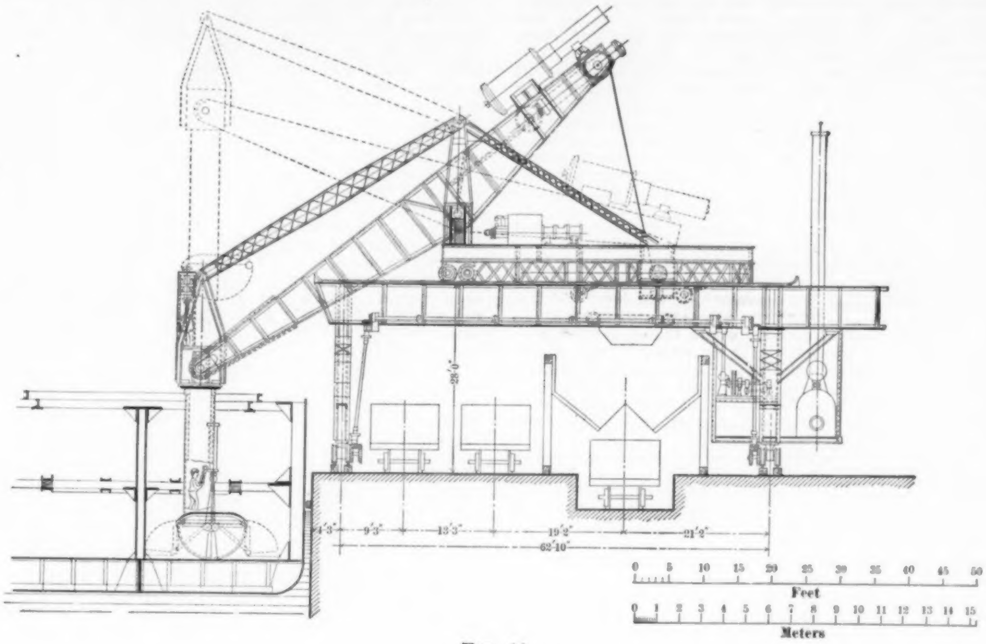


FIG. 14.

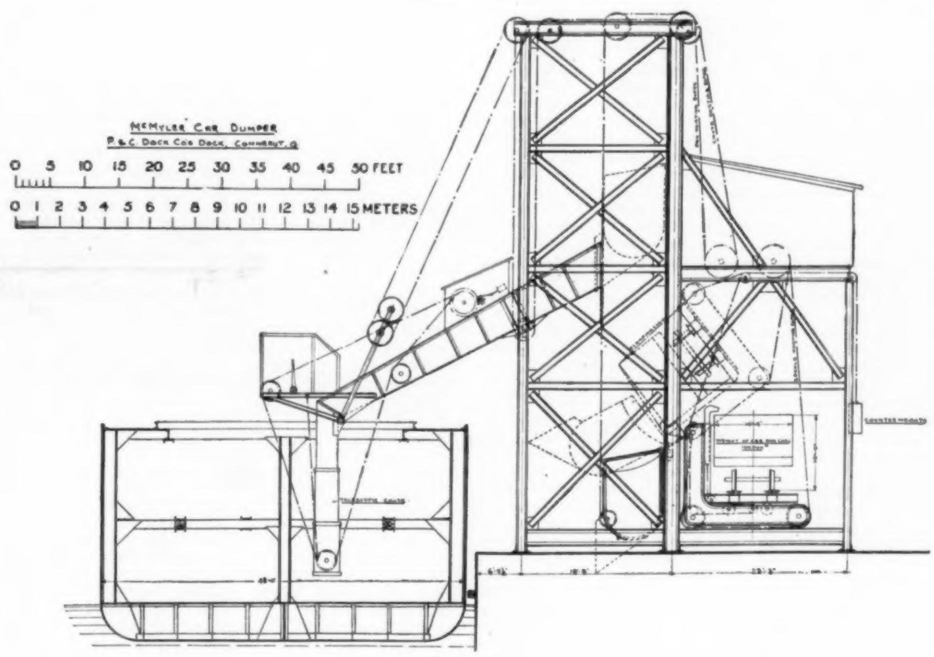


FIG. 15.

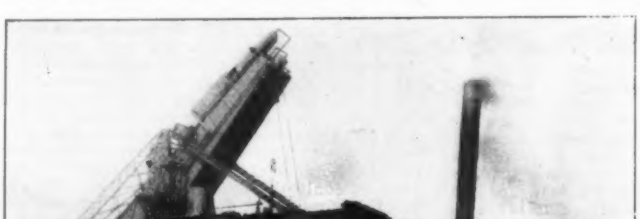
THE PROGRESS OF THE SIBERIAN RAILWAY.

IN view of the activity in China of European interests and the influence which is produced thereby upon everything relating to communication with that part of the world, the progress of the trans-Siberian railway is a question of very present interest. Two recent papers before the Société des Ingenieurs Civils de France bear upon this subject; one, by M. Platon Yankowsky, upon the crossing of Lake Baikal, and the other a review, by M. A. Jacquin, of the communication of M. Ziffer to the Austrian Society of Engineers upon the railways of Siberia in general. To these may be added an article by Herr F. Theiss, in a recent issue of Glaser's Annalen [Engineering Magazine] upon the Manchurian railway, and the importance of Port Arthur considered as a Russian naval station.

The crossing of Lake Baikal, with which M. Yankowsky deals, is a peculiarly difficult problem, since it involves the transport of trains by ferry, through heavy ice, over a rough body of water for a distance of about forty miles.

It is ultimately intended to replace this lake crossing by an all-rail route around the end of the lake, and two routes have been surveyed for this extension. One of these is about 85 miles long, and the other 190 miles; the longer route, which will probably be adopted, making a circuit to follow the Irkout River, and involving a tunnel more than two miles long, piercing the Zyrkouzoune Range. This section of the railway will probably not be completed until 1903, and with the still uncompleted Manchurian section, must be finished before the complete railway across Asia is an accomplished fact. In the meantime, the Lake Baikal ferry will continue to be used, and even after the section around the lake is completed the ferry will probably be maintained for some trains, because of the shorter distance.

The necessity for using powerful ice-breaking boats, having a draught of 20 feet of water, required the construction of landing piers extending out into the lake to deep water. The pier connected with the western section of the railway, at the Lake Baikal station, is 1,800 feet in length, and that at Missovaia, on the other side of the lake, is 1,200 feet long. These piers are constructed of wooden caissons, filled with stone, each being made in the form of a fork, with two branches of unequal length. The longer branch of the Y extends out into the lake, and the shorter branch extends along the shore, the ferryboat entering into the protected space between. A special form of hinged bridge enables the varying height of water to be pro-



FIGS. 12 AND 13.—HULETT ORE UNLOADER, BUILT BY THE WEBSTER, CAMP & LANE MACHINE COMPANY FOR THE PITTSBURG AND CONNEAUT DOCK COMPANY.

vided for in running the trains upon the ferryboats. Powerful electric lights, forming lighthouses of the sixth order, are erected upon the moles in order to guide to the entrance.

The chief interest, however, is centered in the boat "Baikal," a powerful ice breaker, constructed partly upon the plans of the American ice-breaking ferryboats, "Ste. Marie" and "St. Ignace," used on Lake Michigan, and partly on the model of Nansen's polar ship, the "Fram." The "Baikal" is 290 feet long, by 57 feet beam amidships, and 26½ feet deep, with a forward draught of 20 feet. The total displacement, including 580 tons of water-ballast and 250 tons of coal, is 4,200 tons. There are three propelling screws, two in the stern and one at the bow, these being driven by three triple-expansion engines of 1,250 horse power each. The two stern propellers enable a speed of 12½ knots to be maintained in smooth water, while the three screws drive the boat easily through solid ice 3½ feet thick at a speed of about 3 knots. The "Baikal," as an ice breaker, is second only in power to the "Ermak," constructed by Vice-Admiral Marakoff for the winter service in the Baltic.

M. Yanowsky's paper gives interesting details about the construction of the piers and connections, as well as data concerning the operation of the ferry service.

The general review of the Siberian railways, by M. Jacquin, is devoted mainly to the trans-Siberian railway, which is treated in its several sections, giving details of character and construction of each portion, and of the population and nature of the territory. There are also given valuable data concerning projected railways, of which the greater number form branches of the main Siberian line.

Including the various branches of the Siberian system, from the western section, starting at Tcheliabinsk, and opened in 1896, to the last portion of the Eastern Railway of China, the Manchurian section of the Siberian railway, to be completed in 1906, the railways of Siberia foot up a total of 7,639 kilometers, or 4,740 miles, at a total cost of 982,116,250 francs, or 128,566 francs per kilometer.

The great effort of Russia, ever since the days of Peter the Great, has been to obtain a naval station in waters open and free from ice the whole year round. In Europe both Cronstadt and Archangel are closed in winter, while the outlet of the Black Sea is in the control of other powers. Vladivostock, the original port selected as the terminus for the Siberian railway, is closed for several months in each year, while Port Arthur, situated most advantageously on a peninsula on the Yellow Sea, between Corea and the main coast of China, has only a thin sheet of ice on the inner bay for two or three weeks in winter, and the main roadstead is entirely free from ice at all times. It was to secure this coveted port which led to the negotiations by which the Russian government acquired the privileges of diverting the eastern section of the railway through Manchuria, and although the nominal terminus is still at Vladivostock, the spur of railway leaving the main line at Hulan and running southward to Port Arthur, is practically a division of the main line, and destined to become most important.

The entrance into the bay of Port Arthur is about one-quarter mile wide, and a little more than one-half mile long, the main, or western harbor being separated from the outer roadstead by a hilly peninsula, called, from its form, the "Tiger's Tail." The so-called eastern harbor is really an artificial basin, formed by deepening and inclosing a fresh-water lake, and is about 16,000 feet long by 1,000 feet wide, and capable of receiving the largest battleships. This basin is about 32 feet in depth, and is inclosed by granite seawalls, upon which are mounted numerous cranes and electric-lighting standards. The harbor is surrounded with warehouses, machine shops, and other buildings, and there are two docks, one large one for warships, and a smaller one, adapted for torpedo boats, destroyers, etc. On the peninsula, which separates the western harbor from the outer bay, is the location for the torpedo arsenal, and a small drydock for the reception of torpedo boats. Here are also numerous workshops, a training school for mechanics, and vaults for the storage of explosives. The town itself, with a population of about 50,000, lies to the north of the western harbor.

The fortifications of Port Arthur, which were originally designed according to the plans of Hannecken, were carried out later by English and French engineers, and these works have since been extended by Russian engineers so thoroughly that the place is now undoubtedly a fortress of the first rank. The fortifications on the hills on the sea side of the town include a number of forts fully equipped with Krupp rapid-fire guns. During the past year the Russian government has spent upon harbor improvements, including docks, workshops, floating cranes, barracks, etc., about 11,000,000 rubles.

THE PROGRESS OF INVENTION.*

I AM going to ask you this evening to review some of the inventions and improvements of the last hundred years and compare them with what had gone before, noting the various steps in the advances which have been made. I think it is the general impression that all, or almost all, of the conveniences of modern civilization are the product of the nineteenth century, and, in a sense, this may be so; but when I came to look into the matter, I was most forcibly struck by the fact that almost every important invention of which we are now enjoying the fruits is built upon a foundation laid more than a hundred years ago. Sometimes this foundation was a mere idea, a dream, or a mere scientific fact, but often it was a solid foundation of a conception partially or wholly carried into practice.

What marks the nineteenth century is not so much an abundance of broadly new ideas, as the perfecting, completely carrying out, bringing into general use, and finding new applications for inventions which had already been made or partially made, and which had also, in some cases, already been more or less carried out, although generally in a very crude form. In saying this, I do not for a moment wish to belittle the work and achievements of the last hundred years; on the contrary, I wish to impress upon you that the mere conception of an invention, or the carrying of it out in a crude form, does little in itself to benefit the world, although it must also be borne in mind that an invention cannot be carried out before it is made.

Perhaps the two most important inventions which can fairly be said to belong wholly to the nineteenth century are the Bessemer process and the dynamo; for although some small part of the foundation of both of these was laid in the eighteenth century, the inventions themselves had in no way been suggested. Now before the date of Bessemer's invention, 1855, it was well known that the difference between cast iron and steel was that one contained more carbon than the other, and it had also been suggested that the superfluous carbon could be burnt out of cast iron by blowing air through it. What Bessemer did was to devise a practical method and apparatus for carrying out this suggestion, and to demonstrate that sufficient heat could be generated in this way to keep the iron in a molten condition, for the iron requires to be raised to a higher and higher temperature to keep it liquid, as it gradually becomes deprived of the carbon originally in it.

Again, who invented the dynamo? Faraday in 1821 invented the electro-magnet. Faraday in 1831 discovered that a current was produced by moving a conductor in a magnetic field. In 1833 Saxton applied this principle and devised a magneto-electric machine. Subsequently others replaced the permanent magnets of the magneto-electric machine by electro-magnets excited by a battery, and in 1863 Wilde replaced the battery by a small subsidiary magneto-electric machine. In January, 1867, Siemens patented a machine in which the coils were excited by a battery at starting, and afterward by the machine itself; and in March, 1867, Wilde patented a machine which was wholly self-excited. Among all the fields of inventions, probably the greatest advances have been made in applications of electricity and magnetism. Let us, then, review what was known in the eighteenth century and in the first few years of the nineteenth. Frictional electricity and magnetism were known at a very early date. The first practical application was the mariner's compass, which is believed to have been invented by the Chinese, and which came into use in Europe about 1200 A. D.

The electric telegraph was used in a crude form by Watson as early as 1747, by Benjamin Franklin in 1748, Lesarge in 1774, and by Cavallo in 1795, but as frictional electricity only was known at those dates, it may readily be imagined that these experiments did not take a very practical or useful form. It is interesting, however, to note that several of these experiments were in wireless telegraphy in the sense that there was no continuous metallic conductor. The only electrical patent I find prior to 1800 is one for the application of frictional electricity to medical purposes. The celebrated frog experiment of Galvani was made in 1791, and in 1800 Volta announced the discovery of the voltaic pile, but it was not until 1809 that Soemmerin applied it to electric telegraphy. On the other hand, as early as 1801 Sir Humphry Davy produced the electric light, employing a battery of 2,000 plates, each 4 inches square and giving an arc 3 inches or 4 inches long. The electro-deposition of metals was experimented on by Cruikshank, Wollaston, and Sir Humphry Davy in 1804 to 1806.

With the exception, however, of the mariner's compass, neither electricity nor magnetism was put to any practical or industrial use in the eighteenth century, and it was not until some time after the beginning of the nineteenth century that they entered at all largely into every-day life. I need not discuss at length the numerous uses to which they are now put—but certainly, to deprive the world of the electric telegraph, the telephone, the electric light, electro-plating, and electric traction would be to effect a great change; nevertheless it was Volta's invention in 1800 which rendered all these things possible, for although the dynamo is entirely independent of a battery, it grew out of it, and would probably never have been discovered without it. Many important improvements have been made in the electric telegraph since its first introduction; among others may be mentioned Morse's code and instruments, submarine telegraphy, duplex and multiplex telegraphy, both on land and submarine, printing telegraphs, Thomson's receiver, and lastly Marconi's system of wireless telegraphy. In lighting by the electric arc there has been no very striking improvement since its discovery in 1801 by Sir Humphry Davy, although, as is almost always the case, there have been numerous minor inventions of importance; but the history of the incandescent lamp is very interesting. The first patent with which I am acquainted for an incandescent carbon conductor in a vacuum was granted to King in 1845. This, like several of the subsequent inventions on the same lines, was, as we now know, doomed to failure from the commencement, for in those days it was impossible to obtain a sufficiently good vacuum for a successful incandescent lamp, and it was not till the invention of the Sprengel pump in 1874 that this fatal stumbling block was removed. In 1878 Swan exhibited the first working incandescent lamp, but this had the fault of having the carbon conductor too thick. In 1878 Cheesbrough invented the process of exposing the carbons to hydrocarbon vapor, which is the only way by which they can be made uniform, and in 1879 Edison invented the filament. Cheesbrough's invention is a good example of what often happens—namely, of an invention made for one purpose, for which it is of little or no use, proving very valuable for something else which the inventor had in no way foreseen. The object aimed at by Cheesbrough in exposing the heated carbon conductor to hydrocarbon vapor was to fill up the pores of the carbon and so produce a denser and more homogeneous conductor. The purpose for which his invention is now universally used is altogether different; its present use is to make a number of conductors of uniform resistance. The amount of carbon deposited on the conductor increases with the temperature, and therefore if a number of conductors be exposed under the same conditions, those having the highest resistances become hotter than the others, and therefore have most carbon deposited on them, which increases their section and consequently lowers their resistance, and this goes on until all the conductors have the same resistance. Another example of the same thing, and also connected with electric lighting, may be mentioned—namely, the application, which is now so common, of the transformer for reducing the tension of the current between the generating station and the consumer. This was first invented as a solution of the problem of perpetual motion.

The steam engine, as contrasted with the Bessemer process and the dynamo, was for all practical purposes undoubtedly the product of the eighteenth century, being not only invented but also used to a considerable extent, principally for pumping, but also for driving machinery, such as looms and spinning frames, and even steamboats. Putting aside the early experiments of Hero, the Marquis of Worcester, Papin, and others, we come to Savery, who in 1698 took out a patent for his engine, and in 1699 obtained an Act of Parliament extending the term of the patent twenty-one years. Savery's engine first sucked up water a certain height by a vacuum and then forced it up higher by steam pressure. It had a receiver or cylinder—without any piston—which was alternately filled with steam and water. The steam was condensed by a spray on the outside of the cylinder, the vacuum so produced sucking the water into the cylinder. Steam was then admitted at the top of the cylinder, forcing the water out again, and so on. The valves were worked by hand. As may readily be imagined, this engine was very extravagant in fuel, and its success was very limited. Savery used high-pressure steam; it is said that he even went as high as 150 pounds to the inch. Newcomen and Cawley—about 1710—made two very important improvements in Savery's engine. They employed a piston to separate the steam from the water in the cylinder, and they condensed the steam by injecting water into the cylinder instead of by spraying water on to the outside. The latter improvement was accidentally discovered by watching the effect of a leaky piston. About this time Potter, an engine boy, devised a method of automatically operating the valves, so rendering the engine self-acting. Newcomen's engines were very successful and were largely adopted, some of them being of considerable size. Thus, one erected in 1721 had a heating surface of 95 square feet, and consumed £1,000 worth of coal per annum, and another in 1763, in which the cylinder was 74 inches in diameter with 10 feet 6 inches stroke. In 1765 Watt made his great invention of the separate condenser, but it was not practically employed until more than ten years later. Many other improvements were introduced by Watt, among others jacketing the cylinder, applying an air pump to the condenser, working the steam expansively, the double-acting engine, the parallel motion, the ball governor, and a high pressure engine with or without a condenser. He also tried surface condensers, but apparently not very successfully. After 1775 Watt's engines began to come into general use, and some of them were of large size. Thus, as early as 1778 Boulton and Watt erected an engine having a cylinder 63 inches in diameter with 9-foot stroke, which worked a pump 17 inches in diameter at a depth of 318 feet. In 1781 Hornblower invented the compound engine. The main changes brought about during the nineteenth century have been increases in the pressure, the range of expansion, and the piston speed; and, of course, there have been a multitude of more or less important details of construction and arrangement.

The latter end of the nineteenth century has also been marked by the practical application of the rotary steam engine, in the form of the steam turbine. The rotary steam engine was first invented by Hero nearly two thousand years ago, and in one form or another has occupied the thoughts of scores of engineers; but until the last few years it has been of little or no practical use. Some of the rotary steam engines are, however, examples of inventions which, although useless for the purpose intended, have proved of great utility in other ways, namely, as liquid motors and meters, and as pumps both for liquids and gases. The application of the steam engine to marine propulsion was suggested at a very early date. Thus, in 1737, Hull proposed the use of one of Newcomen's engines for the propulsion of a paddle-wheel boat; and steamboats, of a sort, were actually built by Jouffroy in 1781 or 1783, Symington and Ramsay in 1787, Miller in 1788, and Smith in 1793. But steam navigation did not come into anything like general use until the latter half of the nineteenth century. Another important application of the steam engine is to traction on railways. So far as I have been able to ascertain, railways were first introduced in the year 1670. The rails were of wood, laid on transverse wooden sleepers. Ordinary wagons drawn by horses were employed, the wheels having no flanges. No important improvement seems to have taken place till about 1767, when the wooden rails were first covered by flat cast iron plates. In 1776 flanged rails were adopted, ordinary wagons with unflanged wheels being still employed. I have not succeeded in finding out who was the first to introduce flanged wheels, but they seem certainly to have been employed prior to 1800. Railway switches were, I believe, first proposed by Woodhouse in 1803.

The use of steam engines for locomotive purposes seems to have suggested itself at a very early date, but the first actual use of a locomotive on a railway appears to be that of Trevithick and Vivian's engine—patented in 1802—on one of the Welsh tramways in 1804. This was not only the first locomotive railway engine, but also the first direct double-acting high-pressure engine. The boiler was spherical, with the cylinder inside it. The valve was a rotary four-way cock worked by a cam on the crank shaft. Motion was communicated to the carrying wheels by toothed gearing. This engine worked with some success, although the boiler power was insufficient. Stephenson's improvements brought the locomotive practically to its present form, although not to its present size. These improvements were principally fixing the carrying wheels to the crank shaft, the use of side connecting-rods, the steam blast, the use of springs, the link motion, and the application of the tubular boiler, which, however, had before been used for other engines.

The substitution of iron and steel for wood in shipbuilding appears to belong wholly to the nineteenth century. The earliest suggestion I find on the subject is contained in the specification of a patent granted to Trevithick in 1809. Composite ships were patented

* Extract from the Opening Address of the President of the Chartered Institute of Patent Agents, Mr. Edward Carpmael, November 14, 1900. Published in The Engineer.

in 1839, but did not come into use for several years, when they proved a great success, especially for sailing ships, many of the most celebrated of the China clippers being built in this way, which, however, is now little used. Armor plating was patented in 1840.

The nineteenth century has seen great improvements in lighting. Prior to it candles, generally of tallow, and lamps burning animal or vegetable oil, were almost exclusively employed. The Argand burner was, however, invented in 1784. In 1792 Murdoch lighted his house with coal gas, and in 1798 the works of Boulton and Watt at Soho were lighted in this way; but the invention did not begin to come into general public use till 1813. In candles two great improvements were made, both about 1830, namely, the use of stearine and like compounds, and of the self-snuffing wick. Improvements in lamps were numerous, and mineral oil replaced animal and vegetable oils. Drummond invented the limelight in 1824, and the use of magnesium was proposed for lighting purposes in 1864. The electric light, although invented in 1801, only came into general use comparatively recently; and the latter years of the century have seen the introduction of the Welsbach mantle and of acetylene. In spite of all these improvements, however, candles still hold their own, and the consumption is probably now greater than it has ever before been. The introduction of the electric light has, in fact, made the public demand more light every day, the result being that although the electric light competes seriously with other lights, yet its introduction has nevertheless had the effect of increasing the demand for them also. Just the same thing happened with railways, which it was prophesied would exterminate horses, whereas, on the contrary, they, in fact, increased the demand.

Spinning is a very ancient art, and is mentioned in the books of Genesis and Exodus, and the spinning wheel has certainly been in use for many centuries. Driving the bobbins and spindles separately is as old as 1681, and the self-acting mule was invented by Crompton about 1779, but he was not very successful, and the first really useful self-acting mule does not appear to have been built until 1825. Looms for weaving have also been employed from time immemorial. Mummy cloth has been found having no less than ninety warps to the inch. Power looms came into use in 1790, and the Jacquard was invented and introduced in 1800. As in most other arts, many improvements have taken place during the last hundred years. Perhaps the most striking of these is the weaving of two-pile fabrics face to face and then cutting them apart. This was suggested in 1824 by Wilson, and was afterward used to a certain extent for carpets, and then Lister—now Lord Masham—applied it successfully to velvets and plushes, with the result of creating a new and very large manufacture of such fabrics in this country. To Lord Masham also, in conjunction with Donisthorpe, is due the introduction of wool combing by machinery. Prior to their inventions, although crude machines had been devised and even used to a small extent, practically all wool was combed by hand, whereas now hand combing is unknown. Knitting machines and traverse warp machines seem both to have been invented in the eighteenth century, but have since been much improved and come into more general use. Attempts were also made in the eighteenth century to manufacture lace by machinery, and net was made commercially, but the first successful machine for making ornamented twist lace was not patented till 1809, and Lever's machine not till 1813. Many improvements were made in the first half of the nineteenth century, and wonderful results were produced, but the tendency of modern times has been to abandon the use of the more complicated machines, and to make only comparatively simple fabrics. The most noticeable invention of modern times is the production of torchon lace on machines very similar to braiding machines.

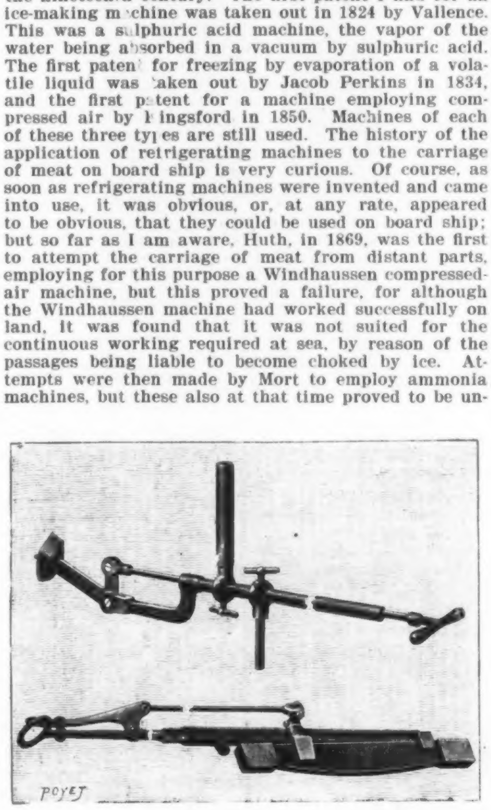
Printing is another comparatively ancient art, but until the close of the eighteenth century it was always performed by hand, the first patent for the application of power being taken out in 1790; but the invention does not seem to have been adopted, at any rate at all generally, for a considerable time, for we find in The Times of November 28, 1814, a statement to the effect that the readers were perusing for the first time a newspaper printed by steam-impelled machinery. Stereotype printing was invented in 1725, lithography in 1800, and cylinder printing in 1790. The improvements of the nineteenth century have been very numerous and important, of which the following may be mentioned: Curved stereotype plates by Cowper in 1816; printing on a continuous web, invented by Rowland Hill in 1835, and carried out by MacDonald in the seventies; and Baxter's invention, also made in 1835, which forms the foundation of all modern color printing.

Another great invention made in the eighteenth century, but not largely adopted until the nineteenth, is the hydraulic press invented by Bramah in 1795. All modern hydraulic machinery is based on this invention.

Small arms and ordnance form a typical subject, for while most of the ideas on which modern weapons are based are very old, yet nevertheless, owing to bad workmanship, the want of proper tools, and of minor, yet essential, details, and, above all, the absence of a suitable cartridge, these ideas were not utilized until the nineteenth century. Thus rifling and breech-loaders were invented several hundred years ago. A breech-loading magazine gun was made by Cookson as early as 1586. A breech-loading revolver was patented by Buckle in 1717, and a single trigger double-barrel sporting gun, having a lock similar in almost all essentials to that of the most modern form of weapon, was patented by Joe Manton in 1792. The use of fulminate ignited by percussion was patented in 1807, but the invention had been employed by others prior to that date. It is mainly the invention of the cartridge making its own gas-tight joint and carrying its own ignition, and the substitution of steel for iron, that has rendered the modern forms of small arms and ordnance possible. Breech-loaders, as above stated, were invented long ago, but they did not come into use because it was found impracticable to design a breech mechanism which could be opened and closed quickly, but which would nevertheless make a gas-tight joint. The made-up cartridge for ordnance is now often replaced by the obturator, but the obturator was suggested by the cartridge, and the idea is the same—namely, that the tight joint does not depend on the fit of the breech block. The principal improvement in ordnance is the introduction of the divided breech screw, but even this is alleged to have been invented some hundreds of years ago.

Practically no change has taken place in the method of constructing lighthouses in exposed situations since the Eddystone Lighthouse was designed by Smeaton in 1756, but great improvements have taken place in the optical arrangements. The light which was first exhibited in the Eddystone Lighthouse on October 16, 1759, consisted of twenty-four large tallow candles suspended in a chandelier. In the year 1807 the chandelier and candles were replaced by a reflector frame fitted up with Argand burners and parabolic reflectors of silvered copper. Since then there have been further great improvements mainly based upon Fresnel's invention in 1822 of the dioptric and catadioptric methods of lighting by means of prisms, and the electric light is now largely used.

I have not been able to ascertain when ice or cold were first artificially produced, but probably this was done in the laboratory by means of freezing mixtures at a very early date, but I think it certain that refrigerating machines were not commercially used until the nineteenth century. The first patent I find for an ice-making machine was taken out in 1824 by Vallence. This was a sulphuric acid machine, the vapor of the water being absorbed in a vacuum by sulphuric acid. The first patent for freezing by evaporation of a volatile liquid was taken out by Jacob Perkins in 1834, and the first patent for a machine employing compressed air by Kingsford in 1850. Machines of each of these three types are still used. The history of the application of refrigerating machines to the carriage of meat on board ship is very curious. Of course, as soon as refrigerating machines were invented and came into use, it was obvious, or, at any rate, appeared to be obvious, that they could be used on board ship; but so far as I am aware, Huth, in 1869, was the first to attempt the carriage of meat from distant parts, employing for this purpose a Windhaussen compressed-air machine, but this proved a failure, for although the Windhaussen machine had worked successfully on land, it was found that it was not suited for the continuous working required at sea, by reason of the passages being liable to become choked by ice. Attempts were then made by Mort to employ ammonia machines, but these also at that time proved to be unsuitable for use at sea owing to the leakage of ammonia, which was not only unpleasant, but dangerous. In 1877, however, the Bell-Coleman compressed-air machine was invented, and almost at once came into use, the trade steadily growing, so that only ten years later a million carcasses a year were imported. The Bell-Coleman machine differed very slightly from the Windhaussen machine, and the point of novelty, small as it was, had more or less been foreshadowed in another specification.



TOOLS FOR REMOVING BOILER SCALE AND PUTTING GRATE-BARS IN PLACE.

Chemistry has made very great advances during the past century; indeed, during the greater part of the eighteenth century chemistry could hardly be called a science, and was of little importance as an art. Toward the close of that century, however, a good deal was done; hydrogen was discovered in 1766, nitrogen in 1772, and oxygen and chlorine in 1774, and by the end of the century some thirty elements were known, as against some seventy or eighty at the present time. Perhaps the most striking chemical inventions which have had industrial applications are the discovery of electrolysis in 1801, by Sir Humphry Davy; of benzine, the basis of modern dyes, by Faraday, in 1825; and the use of aniline for making dyes, by Perkin, in 1856. In addition to these, of course, there are thousands of others that have helped to build up the great chemical industries of the world. Chemistry, indeed, now enters more or less into almost every industry; artificial manures are used in agriculture, metals are extracted from their ores by chemical means, and so on. It is a matter for deep regret that one great chemical industry which was started and built up in England, has, owing solely to the want of enterprise and liberality on the part of our manufacturers, almost entirely passed away into foreign hands. I allude to the manufacture of artificial dyes.

The remaining inventions to which I desire to call your attention as having had their foundation laid in the eighteenth century, but which did not come into general use until the nineteenth century, are, the first gas engine, invented by Street in 1794, but gas engines did not come into general use until about twenty years ago. Sewing machines of a sort were used as early as 1750, but the first practical domestic machines were designed by Howe and Thiemonnier about 1865, but were not much used for a good many years. Beet sugar was known in 1747, and its commercial manufacture was started in 1800. Several years later large factories were set up by Napoleon in order to injure our colonial trade. Crude reaping and mowing machines were invented in 1799, but such machines did not come into use till the latter half of the nineteenth century.

Fulton invented a submarine steamboat in 1796, and successfully constructed one. A demonstration of its use was given by blowing up a ship without any visible agency. We can hardly say, however, that submarine boats have ever yet come into general use. Fulton also invented the screw propeller in 1798, but it was fifty years or more before it was much employed. Balloons were known in the eighteenth century, and in 1783 Charles and Robert ascended 3,000 feet from Paris.

When reading accounts of the progress of old inventions, nothing strikes one so forcibly as the waste of time and money invariably caused by breakdowns and bad workmanship. It took Watt four years to get a working model made of his steam engine, and more than ten years elapsed before he was able to get an engine built and in practical work. The cylinder of his first engine was made of block tin, for it was found impossible to construct it of iron, and several years later we find him writing to his partner Boulton expressing his delight at another cylinder, which he had succeeded in making so true that there were very few places in which a half-crown would pass between it and the piston. The first thing an inventor had to do after completing the design for the details of his invention was to build a factory and teach his workmen how to make it. This was the case with Boulton and Watt, with Stephenson, and many others. Similar difficulties were experienced at much later dates, and, of course, have not wholly disappeared even now. The modern rotating printing machine for printing from a continuous web, which is now used in the printing of almost every newspaper in the world, was invented nearly in its identity by Rowland Hill in 1835, but the invention was then useless, because it was quite impossible to make the machine. The paper from which newspapers are printed is a strip some miles long, and if the cylinders of the machine are not true it is obvious that the paper will gradually work to one side. If the roller is only one-thousandth of an inch larger at one end than the other, then after a couple of thousand revolutions one edge of the paper will be no less than 6 inches in advance of the other, and it is therefore clear that an error of anything like a thousandth of an inch is not permissible. Now, in Rowland Hill's day it was impossible to turn rollers to a thousandth of an inch, and his machine was a failure; but some thirty or forty years later, MacDonald, of The Times, succeeded perfectly, and now by the use of the emery wheel the manufacture of such rollers has become easy. In short, so far as regards engineering, perhaps the most characteristic feature of the nineteenth century is the introduction and almost universal employment of machine tools. In the eighteenth century machines of various sorts had already come a good deal into use, but the machine tool was practically unknown, and in consequence extreme difficulty was always experienced by inventors in getting their machines accurately made, and the cost was generally excessive. The introduction of the self-acting lathe and of the planing machine in all their various forms, the emery wheel, the steam hammer, and the hydraulic press, have changed all this, and in going over a well-appointed modern engineering shop one is lost in wonder in trying to picture the state of things which existed before such tools were thought of, and the engineer was dependent almost entirely on the smith and the fitter.

I have now reviewed, in a short and hasty, and, I am afraid, a very imperfect way, a few of the more important fields of invention. In so doing it is more than probable that I have fallen into errors, especially as to the priority and authors of some of the discoveries. In view of the fact, however, that almost every important invention has given rise to a controversy more or less bitter as to who was the true and first inventor, I think that this is excusable, especially as such errors, if they exist, will in no way affect the conclusions I wish to draw. These conclusions are: (1) That invention is a plant of slow growth, a step-by-step process which in many cases takes a hundred, or it may be hundreds or even thousands of years, from the start to the finish, and who can even now venture to say that any one of the inventions I have referred to has reached its final and most perfect form? (2) That to properly foster the growth of invention a patent law is essential, and that this patent law must protect not only strikingly new discoveries, but inventions which consist of small details, or in the piecing together of old parts to produce an improved whole. (3) That anything tending to diminish the protection given to inventors tends also to diminish invention and the progress of manufactures.

BOILER TOOLS.

THE English manufacturing firm of Walker Brothers & Company has recently devised two boiler tools, which are as original as they are useful. One of them is a special hammer for the removal of boiler incrustations through percussion, and the other is an apparatus that permits of easily putting grate-bars in place. The hammer for removing scale is, as shown in one of the accompanying figures, borne at the end of a long arm, which is curved at its extremity, and upon which it is fulcrumed. Upon this arm, which is hollow, slides a rod that is connected with the hammer through a bell-crank movement. Under such circumstances it will be seen that if the solid rod be pulled and pushed alternately, the hammer will be made to strike the internal sides of the boiler, and consequently to detach the scale therefrom. The hollow arm, which forms, so to speak, the principal frame of the apparatus, is provided with two rods that are capable of assuming the most diverse positions, and of being fixed immovably by means of set screws, so as to give a firm bearing point to the entire system. Finally, the tool may be provided with hammer-heads of various forms, according to the duty that it is required to perform.

The apparatus for putting grate-bars in place is still more ingenious. It comprises, in the first place, a stationary rod provided with a handle and terminating in a fork which grasps the most distant extremity of the grate-bar. Upon this principal bar

is fulcrumed a lever which, through a jointed rod and a bell-crank movement, controls the opening and closing of two metallic jaws, which grasp the rear portion of the grate-bar. After the apparatus has been put in place and the lever has been depressed and fixed by means of the hook shown in the figure, the grate-bar will be firmly held in position, and it will be possible to insert it into the fire-box without any fear of its escaping from the jaws. After the grate-bar has been put in place, the lever is freed from the hook and the apparatus is withdrawn. It is needless to say that the apparatus may be used also for removing a grate-bar that it is desired to replace by a new one, and that, too, even when the fire is lighted. For the above particulars and the engravings, we are indebted to La Nature.

THE TOOLS OF THE MARINE BIOLOGIST.

THE scientific study of the sea which constitutes the larger portion of the earth's surface has been prompted chiefly by practical aims. The nature of the currents, the prevalent meteorological conditions, the depth and the bottom-formation of the sea, in a word the entire province of oceanography, these were the subjects to which the scientist has applied his mind. He labored at first not for the sake of science alone, but of commerce primarily. And thus it happens that an intimate knowledge of the sea has been acquired only in late years.

The sailor cares little how deep the water of the ocean may be; he is concerned chiefly with its shallowness along certain coasts. The interest of the zoologist for the curious animals brought up by the lead is to him utterly incomprehensible. Scant indeed was the material which the naturalist was able to gather; and his desire to learn something of the mysterious depths of the sea was never satisfied in the old days. Seldom, we may safely say never, has the naturalist been able to fit out a vessel of his own and to explore the bottom of the sea entirely at his own cost.

It is, therefore, not astonishing that half a century ago the life of the deeper portions of the sea was still a mystery. The naturalist was doomed to sit at his desk and to formulate theories of marine life which often enough led to utterly wrong conclusions. Soon he began to deny the existence of animal or plant life in the mysterious depths to which he could not penetrate. In these abysses of the ocean, he argued, the density of the water is so great, the pressure so enormous, that no creature could live. And if, now and then, the lead did bring up an animal never before known, he concluded that it had been caught in the upper layers of water.

The English zoologist, Forbes, was the first to undertake an exploration of the deeper portions of the sea. As the result of his labors, which were carried on under most unfavorable conditions, and in a most unfortunately selected region, he laid down the doctrine that at depths greater than 2,000 feet there was no animal life. His dictum was delivered in 1843. The great respect with which the opinions of the English *savant* were received, the circumstance that many of his theories had been confirmed by actual experience, lent color to his belief.

Although deep-sea specimens were found in 1860 the origin of which could not be denied, it was purely by accident that the error into which naturalists had fallen was corrected. In 1865 the submarine cable connecting Sardinia with Algiers parted; and when the pieces were raised from a depth of 6,500 feet, colonies of the most various marine animals were found clinging to the outer envelop—species which must have selected the cable for a resting-place in the early stages of their growth. And now there began a series of scientific investigations in which almost every nation took part and by which old theories were completely shattered.

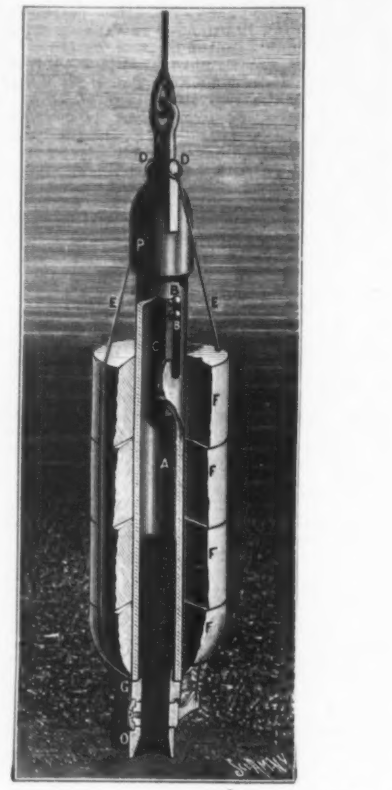


FIG. 1.—MONACO DEEP-SEA LEAD PENETRATING THE OCEAN BOTTOM.

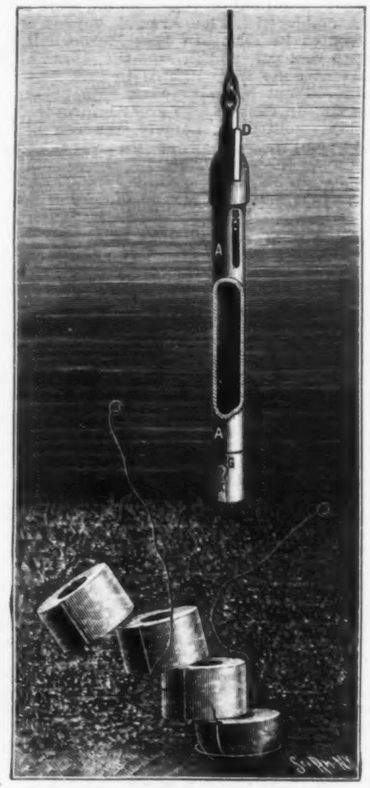


FIG. 2.—THE ASCENT OF THE MONACO DEEP-SEA LEAD.

The exploration of the deeper waters of the sea was therefore resumed where Forbes had left off. It was soon found that at depths greater than 4,000 feet a most remarkable fauna existed. The first impulse to dredge the ocean had been given by a great practical undertaking,—the laying of the Atlantic cable. But during this ever-memorable period Scandinavian zoologists had sent out small local expeditions, the work of which led the great Scotchman, Wyville Thomson, and the well-known naturalist, Carpenter, to fit out the first noteworthy deep-sea expedition. August 4, 1868, was the birthday of marine biology; for on that day Thomson and Carpenter set out in the "Lightning," a vessel which, through the efforts of the Royal Society, had been placed at their disposal by the government. For the first time a drag net was dropped 650 fathoms into the sea. Although the expedition returned in six weeks, the work which it accomplished was of such importance that other expeditions soon set out. A year later Sars, a Swede, Delesse, a Frenchman, and Agassiz, followed the English scientists. Carpenter also set out on a second voyage in the "Porcupine." Between 1871 and 1872 Agassiz and Steindachner, in the steamer "Hassler" made most important discoveries.

These early expeditions revealed a world of which nothing had been even dreamed of. But the work which they performed, noteworthy though it may be, can not for a moment be compared with the results of the brilliant expedition which England, true to her traditions and her position as the foremost of maritime nations, fitted out in 1872 and maintained in active service for four years. The "Challenger," equipped with the most improved instruments, composed of the foremost scientists, returned with specimens and with information which marked a new stage in the evolution of descriptive zoology. What had been found surpassed all expectations. Although the work of the "Challenger" expedition was remarkable, we are perhaps most astonished by the mass of material which was collected. So many were the specimens discovered, that in the opinion of Agassiz, an investigator with the knowledge of eighteen or twenty specialists would require between fifty and seventy-five years of arduous labor to study them.

FIG. 3.—THE MONACO DEEP-SEA TRAP.

FIG. 4.—BUOY FOR THE MONACO TRAP.

The American "Tuscarora" expedition and the German "Gazelle" expedition were not far behind the "Challenger" men in the new field. In 1875 and 1880 the American vessel "Blake" explored the Gulf of Mexico and collected much valuable material. More recently the Austrian "Pola" expedition, the Prince of Monaco, and the German "Valdivia" expedition have added to the wealth of information already gathered.

Our knowledge of the ocean's bottom has been obtained largely by means of the lead and the drag-net. To collect the zoological material, trap-nets are employed; to measure the intensity of the light at various depths, photometric apparatus has been invented; to ascertain the temperature ingeniously-constructed thermometers are used; and to obtain samples of the water at different depths peculiar vessels have been devised.

The first and most important task that confronts the marine explorer is the measuring of sea depths. Nothing seems simpler. It is apparently necessary merely to toss overboard a lead weight of sufficient size, secured to a line of sufficient length and strength. The line could be easily measured; and a piece of tallow on the lead would pick up enough sand to enable one to learn something of the nature of the bottom. If the depths be small, this simple method may answer most requirements; but the errors to which the method gives rise when the depths are at all great renders it necessary to employ more accurate apparatus. Soundings are trustworthy only when the line is absolutely vertical. But the greater the depth to which the lead sinks, the greater is the resistance to be overcome. The downwardly-rushing line becomes heavier and heavier, so that it gradually swerves from the vertical and forms a curve. Perhaps a current may seize and carry the lead still further from its true course. Hundreds of feet of line are reeled off until perhaps 50,000 feet are paid out, and still no bottom

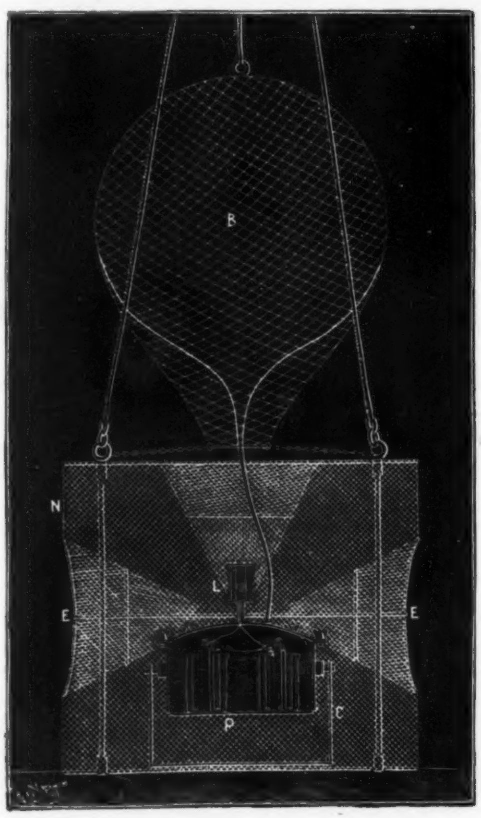


FIG. 5.—REGNARD'S ELECTRICAL TRAP.

is reached. But with our modern methods and improved apparatus, we know that the sounding obtained could not represent more than half the true depth. In parts of the Gulf Stream more than 5,000 feet of line were formerly paid out without touching bottom. Now we know that the depth could not have been more than 2,700 feet.

Such errors could be guarded against only by using a heavy weight, so heavy, indeed, that the line was not strong enough to pull it up again. An improvement was, however, made, which bade fair to overcome all difficulties. In 1854, an American, John Brooke, conceived the idea of so securing the weight to a light line that it could be released as soon as it touched the bottom. By means of Brooke's invention, it was possible to employ thin lines and very heavy weights in ascertaining the nature of the bottom. The principle on which Brooke's sounding-lead is based has remained unchanged to the present day. His deep-sea lead comprises a hollow, cylindrical body provided with a closure at its bottom. When the lead enters the bottom, the closure opens, to permit the entrance of sand and gravel; when the lead is hauled up, the bottom is immediately closed to retain the sand and gravel. But still another problem remained to be solved. A hemp line of minimum strength could not be less than one-quarter of an inch in diameter, and, owing to its length, offered considerable frictional resistance. Again an American, W. Thomson, solved the problem. For the hemp line he substituted piano wire hardly 1-25 of an inch in diameter. The next year, the "Tuscarora" expedition reached bottom at nearly 28,000 feet with this new line—the greatest depth attained up to that time.

The very tedious process of hauling up the lead by hand soon gave way to the more rapid method of reeling in the line by means of steam-winches. The most improved winch employed in deep-sea soundings is provided with means for indicating the length of the line which has been paid out and for automatically hauling up the lead immediately after the moment when it has touched bottom.

In this improved machine the wire, after leaving a main drum, passes about a second drum or roller, which in a single rotation pays out exactly one meter of wire. An indicator is mounted on the shaft of the drum, so that the length of wire which has been reeled off may be ascertained at sight.

In order to stop the machine when the lead has reached the bottom, coiled springs are used, which are subjected to a gradually-increasing compression as the wire is paid out. When the tension of the rapidly descending wire slackens, the springs expand, and thereby apply brakes. A small carriage is likewise employed, which runs on an inclined plane, and which

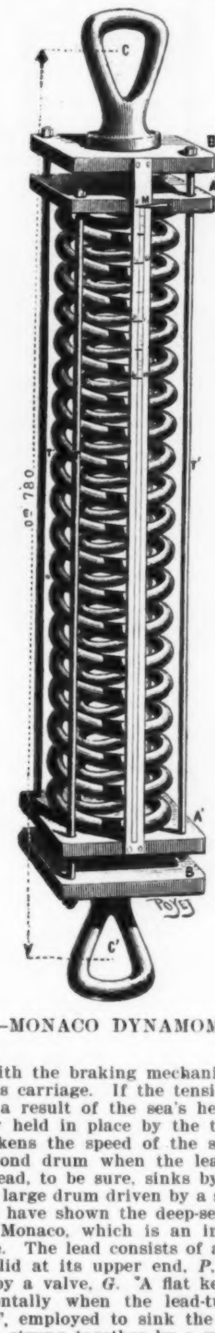


FIG. 6.—MONACO DYNAMOMETER.

is connected with the braking mechanism. The wire passes over this carriage. If the tension of the wire be relaxed, as a result of the sea's heaving, the carriage, normally held in place by the taut wire, runs down and slackens the speed of the sinking lead or arrests the second drum when the lead has touched bottom. The lead, to be sure, sinks by gravity; it is hauled up by a large drum driven by a steam-engine.

In Fig. 1 we have shown the deep-sea lead used by the Prince of Monaco, which is an improvement on Brooke's device. The lead consists of an iron core or cylinder, *A*, solid at its upper end, *P*, and closed at its lower end by a valve, *G*. A flat key, *K* (Fig. 2), projects horizontally when the lead-tube is opened. The weights, *F*, employed to sink the lead are ring-shaped and are strung together by a wire, *E*, secured to a hook or lug on the upper end of the lead. When the device enters the bottom, the cylinder is filled with sand, gravel, slime, or mud, whereby a plate, *C*, is forced upwardly to engage a releasing device, *B*, which unhooks the ring, *D*, by which the weights are held. As the weights fall, the key, *K*, is pressed into a recess, and the cylinder-valve closed.

Besides the Monaco device, the Belknap lead fitted with the Sigsbee releasing device, and Stellwagen's lead are used. The Belknap contrivance consists of a 15-pound cylinder which, upon striking bottom, opens a valve. As the lead is hauled up, the valve is closed. A cast-iron ball is employed to sink the device. The Stellwagen lead is provided with a small, cup-like receptacle, suspended like an inverted mushroom. In this receptacle a specimen of the bottom soil is collected. To prevent the loss of the specimen, a leather cover is used, which is pressed by the water into proper position. The lead is not directly connected with the piano wire, for the wire must not be sharply

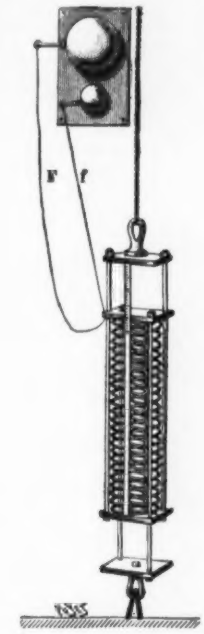


FIG. 7.—DYNAMOMETER CONNECTED WITH SIGNAL.

FIG. 8.—ARRANGEMENT OF THE DYNAMOMETER COILS.

bent, but is connected with the piano wire by a hemp line.

On the "Pola," piano wire 0.9 millimeter in diameter was used, which weighed about 6.5 kilogrammes (14.3 pounds) per 1,000 meters (3,280 feet), and which withstood a breaking-strain of 180 kilogrammes (396 pounds). The wire used for the deepest soundings (4,400 meters—14,432 feet) can be easily carried in one's pocket. The wire used by the Prince of Monaco on the "Hirondelle" was 1.1 millimeters in diameter, and had a carrying capacity of 140 kilogrammes (308 pounds) per square millimeter. One thousand meters (3,280 feet) weighed 7.41 kilogrammes, and cost 7.41 francs. On the "Princesse Alice," the Prince used a steel line, 2 millimeters in diameter, and composed of several strands.

After having made his soundings, the zoologist is ready to begin fishing. Until very recently, the apparatus employed consisted merely of improved English and American modifications of ordinary devices

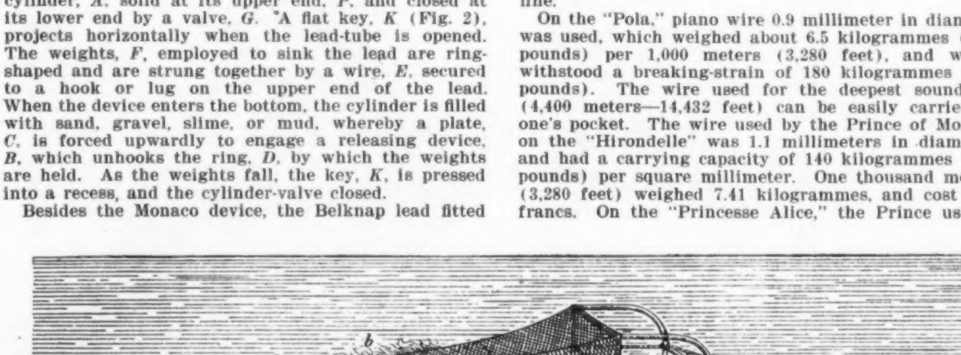


FIG. 9.—*a*, HOOP-TRAWL; *b*, HEMP BOBS; *p p*, WEIGHTS.

used in practical fishery. To the dredges which constitute the major portion of these contrivances, the Prince of Monaco has added a deep-sea net.

When it was found necessary to compare the organisms of the middle and deep layers of water with the life of the upper surface, known by the name of "plankton," trap-nets and surface-nets of more or less merit were invented. The preferred contrivance for bottom work is the hoop-trawl. Two large hoops connected with a rigid frame by iron tubes about 6 to 10 feet in length serve as a support for a strong net some 15 feet in length. In order to prevent the escape of the animals captured, a funnel-shaped net is placed in the interior And in order to prevent the escape of the very smallest animals, the end of the net is provided with a very fine-meshed net. The main net, made of strong hemp cord or of cheap cotton, is coarse-meshed to prevent clogging with slime. The Prince of Monaco fastens two or three weights of 15 kilogrammes each to the tow-line, and one to the small end of the net. By this means the net is kept in proper position on the bottom of the ocean.

The hemp bobs dangling from both sides of the net serve the purpose of entangling minute animals which would escape from the traps. It is true that the catching of fish and animalcules by this method is *un peu brutal;* for the creatures are so mutilated as they are dragged along the bottom, or so grievously injured as they are hauled, that they reach the surface sometimes in a most deplorable condition. The hoop-net is evidently a modification of the common fisherman's beam-trawl.

The difficulty of obtaining unmutilated specimens by means of trawl-nets and dredges induced the Prince to employ pounds and traps, which are not open to the objections mentioned. Apparatus made entirely of metal were so heavy and were so easily lost that the Prince deemed it advisable to employ wood and hemp, which he found gave excellent results. The frame of his trap (Fig. 3 [*1*]) resembles a triangular prism in form. Two frames, equilateral triangles both, made of iron rails 5 feet long, are connected by wooden spars to form a rigid support. Hemp cord is used to bind the parts together. To the inside edges of the framework thus formed a fine-meshed net is fastened. The fish enter the trap by passing through inwardly-tapering brass-wire funnels provided with fine, flexible wire points, which prevent the escape of the fish. In connection with this apparatus, the Prince employs small auxiliary exterior and interior traps (Fig. 3 [*a*]) to protect small, feeble animals from their strong and rapacious foes. The trap is sunk by stone-laden bags (*b*) suspended from the ends of ropes running along the frame-members (Fig. 3 [*2* and *3*]), and from a sling at the upper part of the trap, to which the main line is attached. Within the trap codfish meat and pieces of some glittering article are placed to attract the fish. Since the trap must of necessity be submerged for many hours, the line (wire) by which it is suspended is secured to a buoy (Fig. 4) composed of sheets of cork and tied to a float upon which a flag is carried.

A trap used by the Prince for capturing specimens in water of moderate depth is provided with electrical means of illumination for the purpose of attracting fish. Within this rectangular trap (Fig. 5) a battery, *P*, is arranged, the current of which is fed to the lamp, *L*. An air-bag, *B*, is connected with the battery-box and serves the purpose of so regulating the pressure within the box that the parts will not be crushed by the external pressure of the superposed mass of water. The entrance, *E*, to the trap is similar to that of the previously-described apparatus.

An important accessory of all the contrivances thus far enumerated is the dynamometer. The strain on the wire at any moment must be known, and provision made for relieving that strain, to insure the preservation of the instrument and wire.

The Prince of Monaco has devised a dynamometer composed of strong steel springs which are compressed by the downward pull of the load. Between two plates (*A*, *A′*, in Fig. 6) two springs are so arranged that their coils are opposed to each other (Fig. 8) so as to prevent a lateral bending. The upper plate, *A*, is caused to slide on two guide rods, *T″*, toward and from the lower plate, *A′*, when pulled upon by two other rods, *T*, connected with a rigid lower terminal plate, *B′*. The plate, *B′*, is provided with an eye, *C″*; and the guide rods, *T″*, are connected above with a similar rigid plate, *B*, also carrying an eye, *C*. By reason of this construction the parts *C*, *B*, *T″*, *A′*, coact to form one system and the parts, *C″*, *B′*, *T*, *A*, a second system. The upper movable plate carries a pointer, *M*, which plays over a fixed scale and indicates the tension in kilogrammes. Two cords (*F*, *f*, Fig. 7) are so connected with two bells that a warning signal is given when the tension on the line is excessive. The instrument was first used on the "Hirondelle" and operated faultlessly.

The dynamometer can be connected with the wire in various ways. On the "Pola" the wire after being unwound from a supply-drum passed over several guide-rollers to the drum of the steam-windlass, thence over a deck-roller and a movable roller secured to the dynamometer, and over a system of guide-rollers to a roller on the end of a boom.

Despite its extraordinary resistant power, the dynamometer is a very sensitive instrument and reduces to a minimum the danger of the wire's parting. Since the carrying capacity and tensile strength of the cable is known, the proper precautions can be taken to prevent its breakage when the dynamometer shows that the critical point is nearly reached.

Besides the hoop-trawl previously described, the dredge is much used, but has of late fallen into disfavor. The dredge has been used from time immemorial by oystermen. But the oyster-dredge was particularly well adapted to the purposes of the marine biologist, for which reason the Danish zoologist Müller modified it considerably. Müller employed a square iron frame the side members of which were composed of tapered outwardly inclined rails. From the four corners iron rods extended, which were joined at one end to form a means to which the wire could be secured. Each side of the device could be used to loosen the sand or gravel and collect it in a net or bag attached to the square iron frame. The instrument was employed for nearly a century and was then improved by Dr. Robert Ball. The square form was abandoned; the frame became an oblong, about 6 inches high and 18 inches long. On the "Challenger" this dredge was used with most excellent results. More improvements and modifications were made; the dredges grew in size and increased in efficiency, when it was discovered

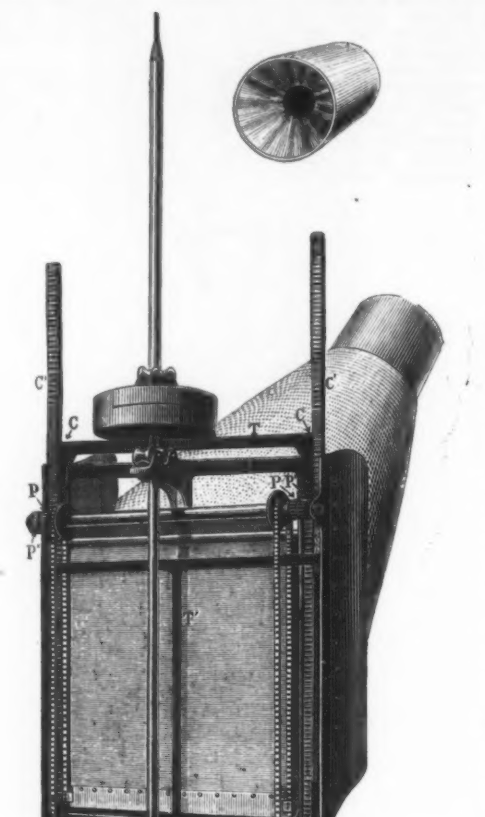


Fig. 10.—TRAP CLOSED, READY TO BE HAULED TO THE SURFACE.

how rich was the life of the deep sea and how wrong had been the conclusions of Forbes.

But even after Sigsbee had considerably perfected the dredge, it was felt that a more efficient apparatus was wanted. The small opening of the dredge was too small to permit the entrance of large animals and still large enough to permit the escape of the very active little animals which abound in the sea. Moreover, plant-like forms were often destroyed; and the net was too frequently clogged with sand, slime, and

Fig. 11.—THE GIESBRECHT TRAP OPENED.

gravel. The zoologist was generally badly repaid for hours and hours of work by a haul of ordinary minerals, mud, and a few shells. The dredge is now used only by the physicist who desires to secure better samples of the bottom than could be obtained with the lead. As a general rule, hoop-trawls have given good results. But the hoop-trawl, whatever may be its merits, cannot be compared in efficiency with the Monaco deep-sea traps.

When it was found that the slimy bottom of the ocean was the habitat of marine animals, biologist-inventors began to devise traps for the capture of animals at all depths. The mere sinking of a net is at best but a crude means of collecting specimens. The animals captured are almost sure to be lost in hauling the net up. It is impossible to determine exactly at what depth plant life is no longer to be found. And it is particularly difficult to obtain specimens of those animals and plants which have received the name "plankton," which serve as food for larger creatures, and which produce many extraordinary marine phenomena. The color of the sea by day and its illumination by night are caused by innumerable members of the "plankton."

It is true that with each cast of the net a greater depth can be reached, and individual specimens thus caught compared with those previously captured. But the time expended is hardly commensurate with the results obtained.

Fortunately for the zoologist trap-nets have been devised which open only when they have reached the desired depth and which close at that depth. The most improved net of this type is one invented and used by the Prince of Monaco.

The first step in fishing with the Monaco trap is the sinking of a guide wire of a length equal to the depth to be attained. The end of the wire carries a heavy weight attached to a tube two meters in length. Closed by a strong cloth curtain, the apparatus slides down the guide cable on two pairs of rollers, guided by two vertical iron plates which check rotary movement. When the apparatus strikes the weight, the curtain is rolled up by a special mechanism and the trap opened for any desired time. The trap is closed by a second weight which is sent down on the cable and operates the curtain-controlling mechanism by its impact.

The apparatus, as shown in Fig. 10, comprises a square frame which carries the net and a sheet-metal receptacle containing a silk-gauze trap. Above the frame a roller is secured, upon which the curtain previously mentioned is rolled, very much as an ordinary window-shade. This upper curtain roller is connected by chain-gear with a lower roller, and is secured by a cross-piece with like runs of the chains. According to the direction in which the upper roller is turned, the curtain is raised or lowered. The trap is automatically opened when it strikes the weight at the end of the wire by a novel mechanism consisting of racks, *C′*, connected by a cross-piece above and another cross-piece below. These racks, as they move upwardly, actuate the upper roller through the medium of two pinions, *P′*, whereby the trap is opened. Fast on the roller-shaft are two additional pinions, *P*, which mesh with two additional racks, *C*, likewise connected by a cross-piece, *T*. This second system of racks and pinions is raised and lowered with the curtain. Small detents prevent an accidental closing of the trap. When it is desired to close the trap, a weight is sent down the wire, which weight strikes the cross-piece, *T*, of the upwardly-projecting second system of racks and forces it down. The racks then turn the pinions, *P*, and the curtain-roller on which the pinions are carried, whereby the trap-opening is closed. The apparatus is then hauled to the surface. The Monaco trap was used in the German "Pola" exhibition, but with no very satisfactory results. The opening, it was found, could not always be entirely closed.

Simpler in construction and more efficient in operation is Giesbrecht's net illustrated in Fig. 11. The device has been considerably improved by Dr. Richard, one of the Prince of Monaco's collaborators. Four metal beams, *G*, are hinged at *H′*, so that they may be folded together and that the net, *D*, can be closed by sliding diagonally opposite corners toward each other along the rod, *A*. On the frame, *A E C E*, by which the net and auxiliary apparatus are supported, two wings, *F*, are mounted, which wings serve as rudders and act as checks to prevent a too rapid descent. The trap is sunk like the Monaco apparatus. The striking of the sunken weight carried by the guide-cable releases the locking mechanism, causes the lower members of the hinged front frame to fall, and opens the trap. The second weight *L*, sent down on the guide-cable releases a second locking device, *M*, which holds the upper beams in open position, and closes the trap. Excellent results are obtained with this apparatus.

Since it is of extreme importance to compare the fauna of the surface with that of the depths, no "deep sea expedition" ever starts without the means for exploring the surface. The Prince of Monaco has devised an improved net for this purpose, having an opening of 22 feet and a length of 13 feet.

TEMPERATURE OF THE UPPER AIR.

A generally received opinion has been that the temperature of the upper atmosphere, like that of the deep sea, was subject to little or no variation corresponding to the seasonal variations at the surface of the earth. In the absence of positive data this opinion was not unnatural of late years. The missing data have been collected by means of small balloons containing self-registering thermometers, etc., which are regularly sent up from the meteorological observatory of Mont Souris, near Paris. M. Teisserence de Bort has lately presented to the Paris Academy of Sciences a discussion of the results obtained in 240 ascensions of the sort made during the years 1898, 1899 and 1900. The discussion leads to the following announcement of general interest, as well as to other results too special to be mentioned here.

First—The temperature of free air is subjected during the course of the year to a very marked seasonal variation at altitudes at least as great at 10,000 meters (33,000 feet).

Second—The amount of the seasonal variation diminishes as the altitude diminishes.

The observations discussed showed the average variation of temperature at the surface of the ground to be 63 degrees F.; at 5,000 meters (16,400 feet) to be 58 degrees F., and at 10,000 meters (16,400 feet) to be 54 degrees F. The diminution of the range of variation

as the altitude increases is much less than has been assumed, therefore, and is quite comparable with the seasonal variations at the surface.

AIMS AND METHODS OF STUDY IN NATURAL HISTORY.*

By EDMUND B. WILSON.

I INVITE your attention to an old but still fruitful topic, namely, the aims and methods of study in natural history. It is a well-worn theme, but one that will retain its interest to the naturalist so long as natural history remains a progressive subject; and I venture to think that it was never more timely than at the present period of intense activity in natural science, of rapid development of new aims and methods, and of continually shifting point of view. How great the changes have been in the last twenty, or even ten, years, is, I dare say, hardly realized by many of the younger generation of naturalists to-day. To appreciate their full extent one must be old enough to have passed his student days in the sixties and seventies, at a time when it was still possible to discuss the truth or error of the evolution theory; when the germ theory of disease was itself no more than a germ; when a gastrula or a karyokinetic figure was a thing to be spoken of with bated breath, but not to be looked upon; when there were no oil-immersion lenses or Abbe illuminators, no automatic microtomes, no ribbon-sections, no chromosomes or centrosomes, no shaking of eggs, no "taxes" or "tropisms;" when to adopt the career of a naturalist was to face the imminent prospect of extinction in the struggle with the environment, and to incur the half-admiring, half-contemptuous compassion of one's relatives and friends.

Speaking as I am in the presence of some of those who guided my own first tottering footsteps along the pathway of science, I feel some hesitancy in claiming a place among those veterans of the old guard; but I am nevertheless able to recall days when we had to do without all the things I have mentioned, as well as a good many others, both material and spiritual, that are now considered the very bread of life in the day's work. I will confess, too, that I am old enough to be at times lost in wonder at the child-like serenity with which the modern student will accept many of these matters, which cost such travail of the spirit, and at the distant epoch to which I have referred would have produced a sensation throughout the scientific world. When, for instance, Kleinenberg made the famous declaration, "Es gibt gar kein mittleres Keimblatt," it seemed to us that the sky must fall on such a blasphemy. We have changed all that. Cite those memorable words to-day, at the climax of your cautious discussion of the germ-layer theory, and your *fin de siècle* student merely remarks stolidly, as he reels off a yard or two of ribbon-sections from his Minot microtome, "Of course not; but what is the use of talking about such an antediluvian myth?" It is enough to make Balfour turn in his grave!

I do not propose to review the advance of discovery in recent years, but only to offer a few reflections on the progress of our aims, methods and standpoints, taking as my point of departure Louis Agassiz's delightful little book, entitled "Methods of Study in Natural History," published in 1863. In this work we find a clear and simple exposition of the aims and methods of natural history as they appeared to a great naturalist and teacher before the theory of evolution had wrought its wonderful transformation in natural science. We all know that, as far as that theory was concerned, Agassiz ranged himself on the side of a losing cause, believing, to quote his own words, that naturalists were chasing a phantom in their search after some material gradation among created beings such as that theory demanded, though he was constrained to the admission that "this notion" had a certain fascination for the human mind. I am here concerned with Agassiz's position on this question only in its bearing on his aim and method. It was Agassiz's aim, first, to observe phenomena with all possible accuracy; and, second, to arrange and classify them in order to discover the "natural affinities" of living things. His method, on the all-importance of which he was never weary of dwelling, was that of his master, Cuvier, *comparison*. "The true method of obtaining independent knowledge," he says, "is this very method of Cuvier's—comparison." "The education of a naturalist now consists chiefly in learning how to compare." It was not Agassiz's aim to analyze and explain phenomena, as Darwin was attempting to do. His whole theory of organic creation precluded such an aim; for existing phenomena of life were viewed as the result, not of progressively operating causes, but of special creation, and "natural affinities" among living things were but the expression of creative thought. It was enough for him to observe, compare and classify. In his work one is everywhere struck with the eager and enthusiastic delight that he took in the facts of natural history for their own sake. The keynote of Agassiz's work was, in short, *the love of nature*, and his remarkable success as a teacher was mainly due to his power of inspiring a like enthusiasm in others. Such, in few words, were what seem to me the characteristic features in Agassiz's aim and methods. They may have for us later naturalists a useful lesson, both in their agreement with, and their contrast to, some of the latest *dicta* of modern writers on scientific method.

Leaving aside for the moment the subject of experimental physiology, we may say broadly that the progress of natural history since Agassiz's time has been along three general lines of study, though no very definite line of demarkation between them can be drawn. First came the development of comparative morphology, dominated by Agassiz's method of observation and comparison, but largely inspired by a theory of organic forms that was the very antipode of his own. Here belong the elaborate and exact modern investigations on general and systematic zoology and botany, on geographical and geological distribution, and on comparative anatomy and embryology. In all these, a leading motive was to search for natural affinities and to interpret them in accordance with the theory of evolution. It has been a laborious and persistent quest, carried forward on a vast scale; and there is now hardly a corner of the plant or animal kingdom into which it has not been pressed. Its point of departure was primarily given by the comparative anatomy of existing forms of life, supplemented by that of extinct forms. Almost from the start, however, it was evident that the data derived from those sources were sufficient without the additional evidence afforded by the facts of embryological development. Despite the high degree of validity possessed by the paleontological evidence, the record is, and is likely always to remain, too meager to guide us to the broader results we seek. Without the aid of embryology, comparative anatomy, with all its wealth of data, gives us hardly a hint of some of the most fundamental relations of living things. The high value of the embryological evidence was therefore early recognized; and with the progress of research it played a more and more important role in the examination of geological problems.

It seems a singular irony of fate that Agassiz, an anti-evolutionist, should have singled out as the most important result of his life-work a discovery in embryology, which, in connection with the generalizations of Von Baer and Darwin, was destined to form one of the watchwords of a coming generation of evolutionists. "I have devoted my life to the study of Nature, and yet a single sentence may express all that I have done. I have shown that there is a correspondence between the succession of forms in geological times and the different stages of their growth in the egg—this is all." In another place he urges young students to turn to the study of embryology; for here, he says, lies "an inexhaustible mine of valuable information—where we shall find the true facts by which to determine the various kinds and different degrees of affinity which animals bear, not only to one another, but also to those that have preceded them in past geological times." How little he foresaw the use which embryologists were soon to make of this principle or the lengths to which they would go in its application. It was in that very year that Fritz Müller published the famous little book, entitled "Facts for Darwin," which contained the first clear outline of the recapitulation theory, and marked the beginning of the embryological search for genealogies, continued with so much ardor by Haeckel, Semper, Claus, Dohrn, Balfour and a hundred others. Many of us have eagerly followed the phases of that long quest, or have sought to make our own modest contributions to it. We know how many puzzling problems of comparative morphology it has brought to a solution, how great an impulse was given to the investigation of natural affinities by the formulation of the recapitulation theory by Müller, Haeckel and their followers. I would be the last to question the immense interest and value of the results that have thus been achieved in the field of genealogical inquiry. And yet I believe that when these results together with those derived from all other sources are broadly viewed, we are constrained to the admission that comparative morphology as a whole has thus far solved only minor problems of descent, and that naturalists as a body are beginning to turn their attention in other directions. Let any one who doubts this compare the present attitude of naturalists toward some of the more general problems of descent with that of fifteen or twenty years ago. At that time the burning questions of zoological morphology centered in the far-reaching genealogical hypotheses such as the *Gastraea* theory, the *Trochophore* theory, the *Nauplius* theory, the origin of vertebrates, the origin of metamerism, or the derivation of bilateral animals from medusoid or polypoid forms. They still remain questions of very high interest, but they are no longer the leading questions of the day; and we may as well admit the truth that interest in them is beginning to wane, temporarily perhaps, but unmistakably. It will be worth our while to inquire into the reason for this.

First, we cannot repress a certain feeling of dissatisfaction at the vagueness of our conclusions regarding many of these major problems. Our knowledge of the anatomy and development of the leading types of life is still very far from complete—indeed, the field before us remains so vast that we may never hope to exhaust its possibilities of research. We have, nevertheless, gained a fairly clear view of the general outlines of the system. But have we reached substantial agreement regarding the natural affinities of the great types? In a few cases, yes; but I think the candid naturalist must also reply, in most cases, no. How is it with that time-honored problem, the origin of vertebrates, in one way the most interesting of all, involving as it does our own remote ancestry? How is it with the origin of annelids or mollusks, of echinoderms, of platodes, of round worms or mulluscoids? What are the historical relationships of the higher types to the Cœlenterata, of bilateral to radial forms, or of Metazoa to Protozoa? I dare say most of the morphologists present hold more or less definite views on these questions—if I, for one, am charged with holding such views on the zoological side I shall not defend myself or deny that all these are questions of high interest to me. But have we reached definite conclusions on which we are substantially agreed? I fear that a general discussion of the zoological members of this society would elicit but too emphatic a negative reply, and that a similar symposium of our botanical brethren would not set us a better example of unanimity. I do not doubt that the progress of research will in time bring us much nearer to a definite solution of these great problems; though it lies in the nature of the case, that we can never attain complete certainty. In the mean time, we may as well admit that in the application of the embryological evidence to the broader problems of descent the recapitulation theory has encountered so many difficulties, undergone so many modifications and limitations, that investigators have in a measure wearied of their wanderings through the scholastic mazes of ancestral and secondary characters, of palingenesis and cenogenesis, of primary and adaptive forms and the like, and have sought for new interests and fresh motives of study. This is clearly apparent in the changed character of the more recent papers in embryology, which devote far less attention than those of ten or fifteen years ago to "genealogische Betrachtungen" that once formed their inevitable climax. The relative decline of interest in genealogical questions is partly due, I think, to a healthy reaction against the inflated speculation into which morphologists have too often allowed themselves to fall; but it is also in large measure a result of the growing feeling that the solution of the broader problems of genealogy still lies so far beyond our reach that we would better turn for a time to the study of questions that lie nearer at hand, and are, to say the least, of equal interest and importance.

We here arrive at a consideration of the two other great lines of progress to which I have referred. The first of these includes the modern developments of the cell theory, which have perhaps contributed equally with the evolution theory to the unification of biological knowledge. I need not dwell on the fundamental importance or the fascinating interest of the general results that have been attained in this field. The point on which I would lay emphasis is that investigation in this direction has only in very minor degree been inspired by the evolution theory or influenced by the historical point of view. The study of the cell, whether morphological or physiological, has been inspired by the desire to penetrate more deeply into the mechanism of the existing living body. It has established a fundamental unity in the organization and modes of activity of living things, but it has thus far taught us little or nothing regarding their origin and progressive transformations. The interest of the results of cell-research, therefore, is of a different kind from that attaching to the genealogical problems of comparative morphology, and the one has grown, in some measure, at the expense of the other.

A no less potent influence has been the rapid infusion of experimental methods into morphological research, which forms the third line of progress in question, and is fast becoming the characteristic feature of latter-day biology; and with this we may briefly regard the far older subject of experimental physiology. When we regard the novelty and importance of the results already attained through these methods, it seems strange that morphologists were so long content to leave them to the almost undisputed monopoly of the physiologists; and I think that zoologists must admit further that, until recently, they have lagged behind the botanists in this regard. It would, however, be wide of the mark to maintain that experimental methods in morphology are a new product of the day. Did not Bacon, in the "Novum Organum," urge that living things are especially adapted for experiment, and in the "Nova Atlantis" even project a scientific institution for experimental researches with reference to the problem of variation?* More than a century before our time Trembly, Bonnet and Spallanzani showed how rich a field lay in the experimental study of regeneration; and Darwin later taught us what a wealth of suggestive results could be drawn from the long-continued experiments of breeders of domestic plants and animals. Nevertheless, it is only very recently that a definite programme of experimental morphology has been laid out, and that naturalists have begun to address themselves seriously to the task.

The revival of experimental methods in morphology is only in part due to a reaction against genealogical speculation. It is in at least equal measure due—and here we touch on a point that is vital to my present purpose—to the closer relations that have sprung up between morphology and physiology, and to the *development of comparative methods on the part of physiologists*. Animal physiology, long confined almost exclusively to the study of vertebrates, at last broke away from its earlier traditions and entered upon a new career, in the course of which it amalgamated with morphology. The traditional line between morphology and physiology thus faded away in zoology, as it had earlier done in botany, as naturalists advanced from either side into a neutral zone of inquiry devoted to the physiology of the lower animals and of the cell, to the activities of one-celled organisms and to experimental studies on regeneration and development, and on cell-morphology; while in the study of habit, instinct, variation and inheritance the psychologist and even the sociologist have made common cause with us. We may well congratulate ourselves on such a solidification of aim and on the accompanying increase in the exactness and order of our method, and this not merely because of the value of the results attained, but in no less degree through the revival of interest in natural history, in the older sense of the word, that has accompanied it. We see the signs of this revival in many directions—in precise and far-reaching inquiries into the habits and instincts of insects and birds, and the life of animal communities; in renewed and more accurate ecological studies on plants and animals of almost every group, in the increasing interest in systematic zoology and botany, in the extended examination of the plankton of inland waters and the sea, in the rapid development of exact statistical methods in the study of variation, and in many other ways, among which we should not forget the mention of the development of courses of instruction in the so-called "Nature-Study," and the recent appearance of admirable text-books in which anatomical detail is largely—perhaps too largely—subordinated to the older natural history. I think, too, that we have a right in this connection to point to the influence that such associations as this Society have exerted in widening the range of common interests and fostering the spirit of scientific fellowship and co-operation.

With these changes has come a better understanding between the field naturalist and the laboratory morphologist and physiologist, who in earlier days did not always live on the best of terms. I shall never forget the impression made on me many years ago, shortly after returning from a year of study in European laboratories, by a remark made to me in the friendliest spirit by a much older naturalist, who was one of the foremost systematic and field naturalists of his day and enjoyed a world-wide reputation. "I fear," he said, "that you have been spoiled as a naturalist by this biological craze that seems to be running riot among the younger men. I do not approve of it all."

* Presidential Address delivered at the annual dinner of the American Society of Naturalists, Baltimore, December 28, 1900.—Science.

* Osborn, "Greeks to Darwin," pp. 92, 93.

I was hardly in a position to deny the allegation; but candor compels me to own to having had a suspicion that while there may have been a mote in the biological eye, a microscope of sufficient power might possibly have revealed something very like a beam in that of the systematists of the time. However that may have been, it is undeniable that at that period, or a little later, a lack of mutual understanding existed between the field naturalist and the laboratory workers which found expression in a somewhat picturesque exchange of compliments, the former receiving the flattering appellation of the "Bug-hunters," the latter the ignominious title of the "Section-cutters," which on some irreverent lips was even degraded to that of the "Worm-slicers"! (For the sake of completeness, it may be well to add that at a later period the experimental morphologists fared no better, being compelled to go through the world under the stigma of the epithet "Egg-shakers.") I dare say there was on both sides some justification for these delicate innuendoes. Let us, for the sake of argument, admit that the section-cutter was not always sure whether he was cutting an *Ornithorhynchus* or a pearly *Nautilus*, and that at times perhaps he did lose sight of out-of-doors natural history and the living organism as he wandered among what Michael Foster called the "pitfalls of carmine and Canada balsam;" but let us in justice mildly suggest that the bug-hunter, too, like Huxley's celebrated old lady, was sometimes a trifle hazy as to whether the cerebellum was inside or outside the skull, and did not sufficiently examine that hoary problem as to whether the hen came from the egg or the egg from the hen, and by what kind of process. The lapse of time has in truth shown that each had something to learn from the other. The field naturalist came to realize that he could not attain right conclusions in the investigation of the larger problems before him without more thorough studies in anatomy and development. The laboratory morphologist learned better to appreciate the fact that his refined methods of technique are, after all, but a means toward the better understanding of the living organism and its relation to its environment. On both sides, accordingly, the range of common interests and sympathies was extended; and some of the splendid monographs of recent years bear witness to the value of the results that have flowed from the combination of anatomical, embryological, systematic and ecological research.

(To be continued.)

THE TETE-ROUSSE GLACIER.

On July 12, 1892, there occurred in France a terrible catastrophe, in which an avalanche of mud blotted out part of the villages of Bionna and Fayet, together with the Baths of Saint-Gervais. This accident was caused by the sudden outburst of a pocket of water situated inside the Tête-Rousse glacier, which is at an altitude of 10,725 feet. A mass containing 3,546,100 cubic feet of liquid matter, traveling at the rate of 45 feet per second, or perhaps 30 miles an hour, carried down to the plain of the Arve and into the gorge of the Baths more than 35,461,000 cubic feet of all kinds of material torn from the south side of the Rognes Mountain from the lateral and frontal moraines of the Bionnasset glacier, as well as from the watershed of the little brook of Bionnasset.

After the catastrophe annual explorations were made by the forestry and glacier service of the Tête-Rousse. In 1893 it was noted that the passage through which the pocket emptied was almost completely closed; 1894 this passage was closed and cakes of ice were seen floating on the water which had collected in the cave of ice.

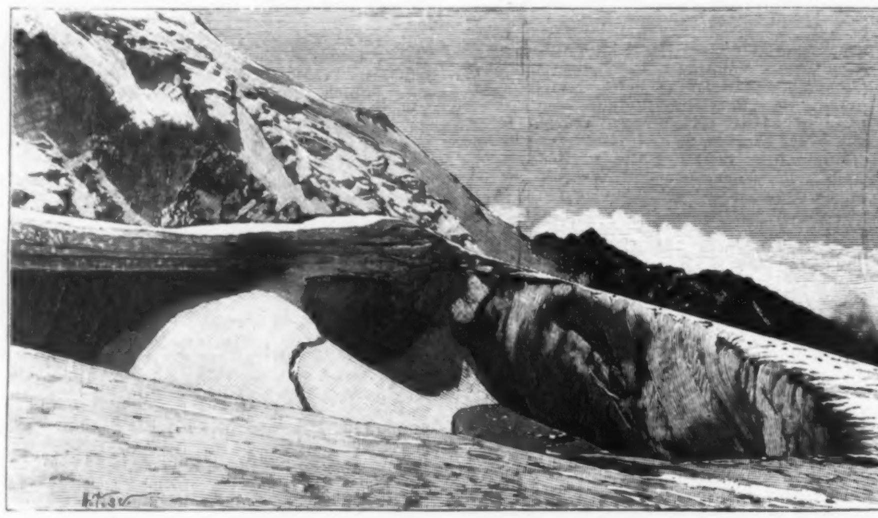
Since 1895 the pocket has been gradually filled by snow falling directly upon it or being driven in by the wind, and by avalanches descending the escarpments of the Gouter Needle (12,732 feet), which dominates Tête-Rousse. In 1897 the glacier had again assumed its normal aspect.

The fear, therefore, of a new sub-glacial lake, hidden from view by a covering of ice and snow, and ready to descend as another deluge in case of the sudden rupture of the frontal side of the glacier was a natural one. This fear, besides, was not chimerical; in the huge mass of Mont Blanc even pockets of water exist in the glacier of the Bossons, the rupture of which has been observed several times.

To prevent the repetition of a catastrophe like that of 1892, the Administration of Forests and Waters thought it best to stop the sudden eruption of water and check its further accumulation by making a permanent exit for it. They, therefore, decided to run a tunnel 43 square feet in cross section in the rocky ridge which supports the Tête-Rousse glacier and separates it from that of Bonnasset, situated about 500 feet below. With this tunnel as an outlet, the water, whatever might be its volume, would pass off harmlessly and without undermining action in the crevasses of the Bionnasset glacier.

In order to carry out this plan it was necessary to run a mile path 6 feet wide a distance of 4,100 feet from the Belleview pavilion (altitude, 5,800 feet) to the plateau of Pierre-Ronde (altitude, 9,288 feet) across the crest of the Rognes Mountain; and then a footpath 3 feet wide by 8,495 feet in length along the ridge which forms the watershed of the valleys of Montjoie and Chamonix. This path is the one most frequented by tourists who wish to ascend Mont Blanc, and it quite merits all their favor, since it enables them to save considerable time, avoid much fatigue, and reach at length, via terra firma and solid rock, an altitude of more than 12,500 feet.

A sheltered hut for the use of the foresters and superintendent was built on the plateau of Pierre-Ronde behind the crest of the Rognes; and as soon as these accessory works were completed, work was commenced on the subterranean gallery, which was started at an incline of 10 in 100. After having dug through 36 feet of moraine, which were stoned up and timbered, the workmen struck rock. Instead of being a compact mass, however, the rock appeared, even at the greatest depths, in the form of blocks soldered together by inclusions of ice. The heat caused by the mining operations, the lamps, and the bodies of the workmen themselves, caused this ice to melt; and more or less voluminous fragments of stone dropped from the roof of the gallery, so that it was found necessary to timber it to prevent accidents. After tunneling for 200 feet ice was reached—the old, hard, dry, sonorous kind, yielding well to dynamite. At 370 feet from the opening the character of the ice changed to the soft, white kind, full of air bubbles and inert under explosives—in a word, the snow changed into ice. Soon, the 30th of June, 1900, water oozed from the sides of the gallery more and more abundantly. Lateral soundings made a little farther along released powerful jets of water, which obliged the laborers to stop work, and some small cracks opened in the ceiling. From vertical soundings made in the floor the water gushed forth, bubbling. The flow at the mouth of the tunnel reached 31,900 cubic feet a day.



END OF TUNNEL OVER SNOW-FILLED OPENING OF POCKET, AUGUST 8, 1894.

OPENING OF POCKET IN THE TETE-ROUSSE GLACIER, SEPTEMBER 7, 1892.

In order to explore all the cavities of the glacier several new tunnels at an incline of 2 in 100 were started from the point where the gallery passed from the rock into the ice. One of these branches came out exactly at the opening observed in 1892, 1893 and 1894 and showed that almost all the space was filled with grained snow-ice, frozen at the surface. Another branch—the longest—was directed toward the lake observed in 1894. A number of vertical soundings showed that there was no longer any accumulation of water in the pocket which was so suddenly emptied in 1892. The soundings also gave the exact contour of the bottom of the pocket, which could not heretofore be determined by surveys.

All this work was carried out with great difficulty at a considerable altitude where the cold, the rarefaction of the air, and the dryness of the atmosphere sorely tried the laborers, anæmiating them, and causing them to lose all appetite, so that the period throughout which one set of men could stand the strain was three months at the most. As a result of the work, the Forestry Commission has concluded that pockets of water no longer exist in the Tête-Rousse glacier, and that consequently the fears formulated in the note communicated to the Academy of Science, August 14, 1893, on the subject of the "reoccurrence in the near or distant future of a catastrophe like that of July 12, 1892," can be entirely disregarded.

The work will also be of great service in the study of glaciers. The future investigations of the forestry service will bear on the following points:

1. To measure the speed of the glacier at its surface and at different depths.
2. To note the supply of the glacier.
3. To determine by means of new soundings the relief of the bottom of the basin in which the glacier rests.

When once obtained, these data will doubtless permit of establishing the relations which exist in the glacier between its slope and its supply.

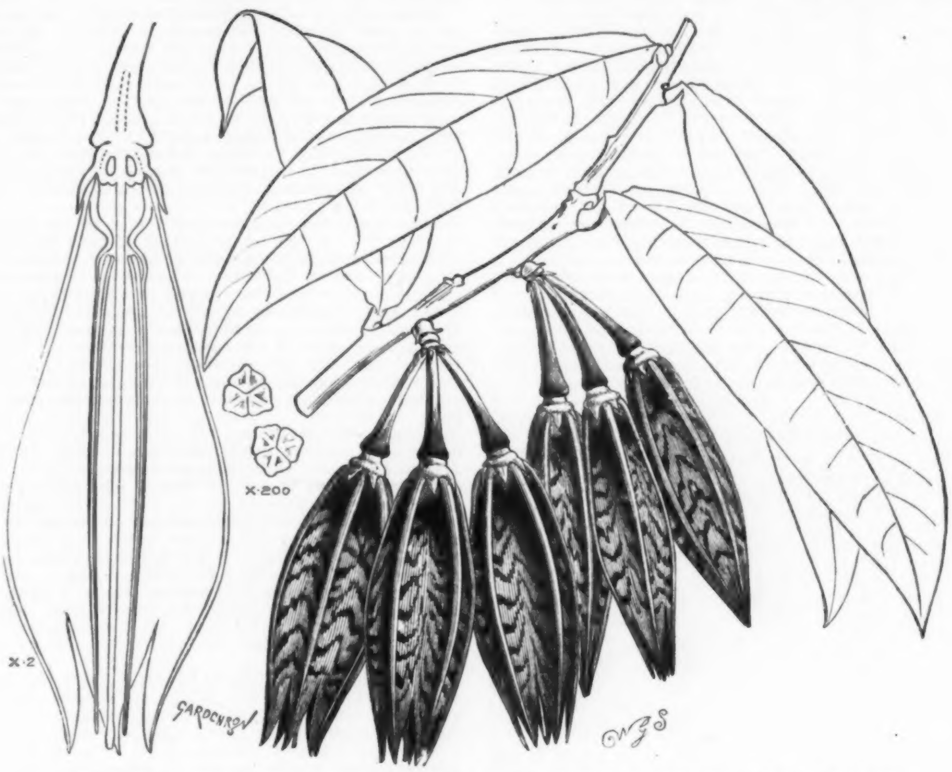
Thus, after having given security to the inhabitants of a whole valley, and after having opened a convenient road up Mont Blanc, the forestry agents will try to bring a new contribution to that part of science which has for its object the determination of the laws which govern the glaciers.—La Nature.

PLANT STEMS UNDERGROUND.

Mr. R. Lloyd Praeger, in the course of an interesting article on "Flowering Plants," in the current number of Knowledge, says: "Subterranean stems may conveniently be grouped similarly into those which produce leaves and flowers throughout their length, or at intervals. In the subterranean stem a further modification takes place as compared with the erect stem. Most erect stems—and prostrate stems, too—are colored green with chlorophyl, that they may assist the leaves in the manufacture of plant-food. The underground stem has no opportunity of doing this, owing to the absence of daylight, and it is usually white, or of the dull colors that most roots affect. Underground stems have likewise little need of strength, except the quiet but well-nigh irresistible strength of growth, by which the apex of the stem forces its way through the soil. Their surface, too, being buried in damp earth, is less exposed to heat and dryness, and need not guard against excessive evaporation; hence we find that underground stems are frequently brittle, with a very thin epidermis or skin. These stems are excellent places for the storage of food-materials, which is the more necessary in such plants, since, the stem being below ground, the leaves and flowers have to grow up often to a considerable height above the surface to secure a due amount of light and air, and perfect the fruit; hence subterranean stems are frequently thick and fleshy—look at those of the butterbur, for instance. An extreme case of the storage of food in stems is found in tubers, such as the potato. In these, a great amount of food material is stored around a few buds, which lie dormant during the winter, and use the food-store in their rapid growth during the following season. Stems may altogether supplant leaves, and undertake the manufacture of the whole food of the plant. The gorse furnishes a well-known example. The seedling gorse has little trifoliate leaves, like the Genistas, to which it is related, but as the young gorse increases in size these leaves disappear, and the green stems carry on the work of leaves, and in addition undertake the defense of the plant against grazing animals by means of the stout thorns in which the branches terminate."

AGAPETES MACRANTHA.

THIS is one of those semi-tropical, hardwooded plants which every one admires, and nobody grows, probably because it is of little use for cut flowers. It was introduced as far back at 1851, and was again shown at the Royal Horticultural Society recently. The general appearance of the plant is well shown. The flowers are of a waxy consistence, deeply five-ribbed, cream colored, flushed with pink, and with deeper V-shaped bars of the same color. The plant belongs to the Vaccinium family



AGAPETES MACRANTHA—FLOWERS CREAM-COLORED, MOTTLED, AND STRIPED WITH PINK.

(*Vacciniaceae.*) The pollen-grains are triangular and three-lobed.

A VOYAGE IN MESOPOTAMIA.

BARON Max von Oppenheim, who last year made a trip through the northern part of Mesopotamia (called by the Arabs Djezireh), gives, in "A Travers le Monde," an interesting account of it, from which we extract the following particulars:

Starting from Ed-Der on the 3d of August, he crossed the Euphrates, and, on the next day, after a long and tiresome march, reached the valley of the Khabour, in front of the ruins of the ancient city of Sawar. The Khabour, which flows along the hill to the east, is here about 98 feet in width. This width remains nearly the same up to the confluence of the Gargar. The Khabour has its source in the Karaga Dagh, to the southwest of Diarbekir. The Gargar, which is a very swift stream, inflects it to the south. The confluence of the Khabour in the Euphrates is a day's march down stream from Sawar, near the ruins of the ancient Roman fortress of Circesium. While the Khabour is relatively well known, the Gargar, to the south of Nisibin, had never been explored. On the 5th of August the baron began the ascent of it, and toward night was in sight of the beautiful long chain of Singar, and, half an hour later, reached the imposing hill of ruins of Margada. The form of this is nearly quadrangular. It is 50 feet in height, and about 600 feet in length. The next day, the baron reached the extensive tumuli of Cheddadeh. As this locality occupies an important point of the caravan route from Mossoul to Der-ez-Zor, it is the seat of a moudir.

On the 11th of August, our traveler reached Arban, called by the Bedouins Agâbé. The ruins of the city are hidden under several hillocks, the largest of which, immediately to the north of the Khabour, has been partially carried away by the waters, so that the face turned toward the river is nearly perpendicular. Old walls made of dried bricks are distinctly recognized therein. Layard, upon forming vertical openings in this wall, made some important discoveries.

To the Arab epoch belong the remains of a large stone bridge—three piers with their arches ornamented with reliefs and inscriptions.

The confluence of Khabour and the Gargar should be moved farther to the north on our maps. From Tell Hesekeh to Nisibin the distance is 270 miles, which was made by the baron in ten days on horseback. The route skirts the Gargar, which is scarcely more than 20 feet in width, but is so deep that fording places are rare even in the summer season. The water is quite limpid. It brings to the Khabour the water of the torrents of the Tour-Abdin, and its course, which is slightly incurved, is quite rapid. It recalls a mountain river of Europe.

The country is at first flat, but soon becomes broken, and gradually rises to as far as to Nisibin. At a few hours' march from Hesekeh, the character of the country becomes transformed, and to the steppes of Central Mesopotamia there succeeds undulating land of fertile aspect.

On the 9th of August, the baron reached Nisibin. After traversing the field of ruins of the ancient city, he directed his steps toward the old church in which is buried Saint James, the founder of the Jacobite religious community. This church, constructed of very large stones, dates back perhaps to an epoch anterior to Christianity. Its rich Corinthian ornaments strikingly recall the temples of Baalbeck and Palmyra. The church is deeply buried in the débris of the field of ruins that surround it.

Above Nisibin, the Gargar is divided into two arms, one of which, the Khounes, traverses the western, and the other the eastern, part of the city. Over the eastern arm passes a twelve-arch bridge, perhaps of ancient origin. By exploring the tumuli under which it seems that a still more ancient city lies, at a considerable depth, important results would doubtless be obtained, for Nisibin is one of the oldest and one of the principal cities of Mesopotamia, and has survived the fall of Nineveh 1,500 years.

The baron had been scarcely two days in Nisibin when he was surprised by the arrival of twenty Bedouins in his camp. The people of Sheik Faris Pacha, who had escorted our traveler from Der-ez-Zor, had told their master that the baron purposed visiting him; and so Faris had sent an escort on horseback. The following day, sending his caravan in advance toward the Chammars, the baron started after it at noon. At five o'clock in the afternoon he came in sight of the Chammar camp. It was not very extensive, and included but 100 or 120 tents. But these did not shelter the entire tribe. On the contrary, the principal camp was situated toward the southeast, at a place where there was more water to be found.

The camp of the Bedouins presented a truly fascinating aspect. As our traveler approached it, the horsemen of his escort resumed their equestrian sports with renewed ardor, and rushed toward the tents yelling wild war cries. Then numerous horsemen came out of the tents to meet them and take part in their tournament. Sheik Faris, standing in front of his tent and surrounded by a few of his people, bade the baron a welcome. Descending from his horse, the baron entered the great division of men. Here, squatting upon the ground, were more than a hundred persons, who rose at his approach and led him to cushions arranged along the wall that separated the men's division from the harem. The hospitality offered by Faris was a very open one, even according to Arab notions. The Sheik not only undertook to care for the baron's caravan, but also his escort of twenty soldiers.

The large Bedouin camps are arranged very irregularly. As a general thing, the tents are grouped according to topographical circumstances or family arrangements. They are quite widely spaced, but in time of peril are placed close together. The tents are always square, and those of the chiefs are very spacious.

In the men's compartments are seen suspended from the walls mats, bedclothes, and cushions designed for guests. In the center, upon a stone, is placed the "kirbeh," from which the guests fill a copper or wooden "taseh" or wash basin. Near the water bottles there is a fireplace or "wigak," composed of a few stones and serving for the preparation of coffee. The latter is made with a certain solemnity by the Sheik himself, his near relatives or a confidential domestic.

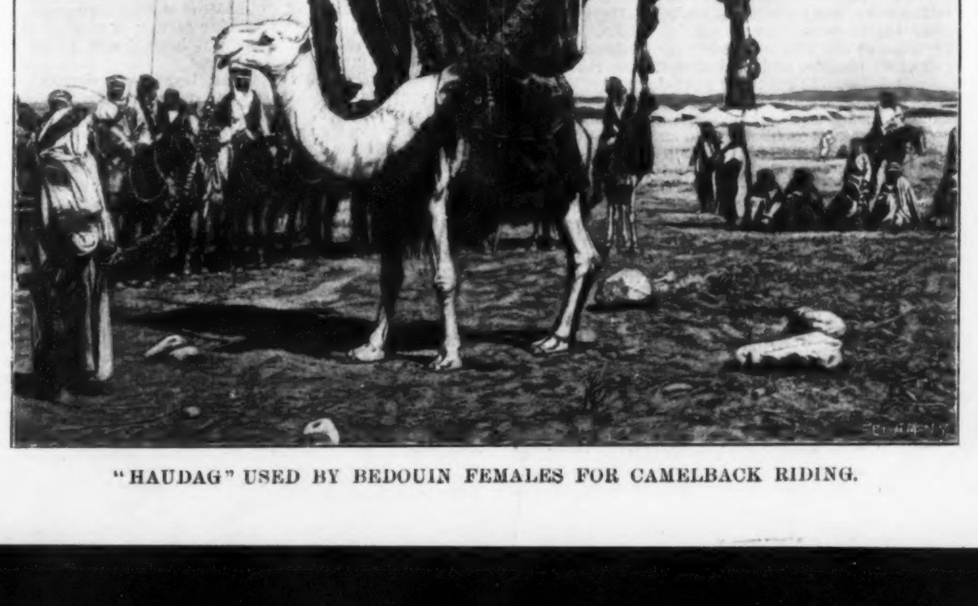
In the women's compartment are usually found piled along the walls the bags and vessels that contain provisions, grain and clothing. Very near is a large stone fireplace. For cooking purposes, tin or copper stoves are employed. The smaller of these are called "tangara," and the larger "dast" and "gidara." In the center is usually placed the "haudag" upon which the woman sits when upon camel back. The haudag is covered with a canopy supported by curved wooden rods and hung with drapery. It is in the women's division, too, that are usually kept the horse saddles and valuable objects when there chances to be any. Particularly expensive garments, women's ornaments and gold and silver are generally preserved in the houses of city friends during the summer season.

In the very large tents, the women's compartment is divided into smaller ones, which are used by the females as bedrooms.

The Bedouin loves his tent, despite the slight shelter that it affords him. He is proud of it and regards the city man in his stone house with contempt. So the efforts of the Porte, which is endeavoring to civilize the Bedouins, by rendering them sedentary, are meeting with great obstacles. The repugnance that these people have for a sedentary life explains how it is that they have never succeeded in forming a nation. The desert of Northern Arabia and Mesopotamia has doubtless been traversed by people of the tent and nomad shepherds from the most ancient times. According to Biblical tradition, Abraham emigrated with his herds from Mesopotamia to the Holy Land, and toward the Red Sea. As far back as we have any documents as to the existence of the Bedouin Arabs, they show us the same civilization as that of to-day.

The first detailed accounts that we have of the political and ethnographic circumstances of Mesopotamia come to us from Strabo in the first century of the Christian era. Strabo expressly says that the whole of Mesopotamia, to the south of the Kurd Mountains, and entire Northern Arabia as far as to the Great Desert, or "Nefoud," are inhabited by Arabs of the tent. These, says he, are brigands and shepherds who emigrate to other regions after they have ceased pasturing their herds and pillaging.

History shows us that some Arab societies, after long leading a wandering existence, have become



"HAUDAG" USED BY BEDOUIN FEMALES FOR CAMELBACK RIDING.

transformed into principalities and states of a certain importance. As an example, may be mentioned, in the first place, the Rassanides in the Haouran and the Lachmides at Hira upon the lower Euphrates. In the following centuries, their method of existence in the desert remained similar to that described by Strabo. New tribes continually emigrated from Arabia toward the north and drove before them the peoples who were dwelling there, and who had to disappear or else become sedentary, and establish themselves upon the confines of the desert. Before the great disorder produced by the introduction of Islamism, the most powerful tribe was that of the Tais. This was so powerful that it was by its name that the Syrians and even the Chinese designated the Arabs. After the establishment of Islamism, the emigration toward the north continued from all parts of Arabia. There are still to be found in Northern Mesopotamia a few remains of the tribes that invaded the country at that epoch. In recent centuries, a few more important movements have occurred, the epoch of which we know by tradition. The tribe that took the leading part in such movements was that of the Chammars, the same that has remained all powerful in Mesopotamia.

The family of the Sheiks of the Chammars dates its origin from the epoch of Mohammed, and therefore calls itself Bet Mohammed.

At present the Chammars are the undoubted masters of the steppes of Mesopotamia, from Ourfa as far as the region of Bagdad. Nearly all of the tribes that live in this territory pay them tribute, or "khoureh."

The constitution of the tribe among the Bedouins is patriarchal, and is founded in great part upon that of the family. The tribe consists, as a general thing, of more or less numerous groups of families connected by ties of blood. The families are called "achair" and the chiefs "machair." At the head of a group is a sheik, selected from among the richest men of the tribes. The sheik, with his family and relatives, constitutes the nucleus of a camp. The union of the sheiks of the different tribes follows the orders of a chief who is sheik of all the tribes, but has no particular title. His power is quite limited; and in all important matters he has to ask the advice of the leading men of the tribe, the "machatair." He cannot give orders, but can only propose. He has the right to decide neither upon peace, nor war, and, in case of war, is not the indicated head of the army. The dignity of the sheik is, as a general thing, hereditary, but the eldest son does not necessarily succeed, although such has usually been the case among the Chammars.

[Continued from SUPPLEMENT, No. 1313, page 21049.]

PROGRESS OF AGRICULTURE IN THE UNITED STATES.

By GEORGE K. HOLMES, Assistant Statistician, United States Department of Agriculture.

Influence of Patent Laws on Development of Agricultural Machines.

THE development and creation of agricultural implements and machines by the inventive genius of this country is one of the most remarkable features of progress of the century. Its history is one of evolution and revolution—a revolution of incalculable consequences to human labor and the production and distribution of wealth, with an immense bearing upon the trend and character of industry, social life, and civilization.

This development has been encouraged by the patent laws of the country, and perhaps nothing could be more tersely expressive of the influence of these laws in promoting mechanical agriculture than a mention of the number of patents that have been granted. Under date of November 17, 1899, the Patent Office reports that patents for agricultural machines had been granted to the number indicated in each of the following classes: Vegetable cutters and crushers, 701; fertilizers, 822; bee culture, 1,038; trees, plants, and flowers, 1,102; care of live stock, 3,749; dairy, 4,632; thrashers, 5,319; harrows and diggers, 5,801; fences, 8,404; seeders and planters, 9,156; harvesters, 12,519; plows, 12,652.

It is no longer necessary for the farmer to cut his wheat with sickle or cradle, nor to rake it and bind it by hand; to cut his cornstalks with a knife and shock the stalks by hand; to thrash his grain with a flail, nor to drive horses over it to tread it out, nor to scrape the ears of corn against a shovel or the handle of a frying pan. It is no longer necessary for him to dig potatoes, nor to cut his grass with a scythe and to spread it with a pitchfork that it may dry, nor to pitch the hay from the wagon to the haymow in the barn, nor to pick the lint from cotton seed by hand, and so on with numerous operations throughout the whole range of agricultural work.

Mechanical contrivances have largely supplanted human labor in many respects, or have improved the application of labor and increased the product of agriculture, reduced the cost of production, augmented the farmer's gross income, and made his life an easier one than it was before the machine period.

This country has come to be without a peer in the manufacture of agricultural implements and machines, both in quality and number. The manufacturing establishments for producing them in 1890 numbered 910, with a capital of $145,313,997, and 42,544 employes, receiving wages to the amount of $21,811,761, turning out a product valued at $81,271,651. One of these establishments (the largest in the world), making various kinds of mowers and reapers, corn harvesters, corn huskers and shredders, and hayrakes, turned out 187,760 machines in 1898, or, on an average, one in less than a minute for every working day.

Agencies for Agricultural Experiment and Information.

Along with the application of invention, have grown up numerous agencies for educating and training the farmer in agriculture, for disseminating information with regard to improvements, and for stimulating among farmers the associative spirit and increasing the benefits to be derived from co-operation.

The first of these agencies, chronologically, consisted of voluntary organizations for the promotion of agricultural interests. These, under various titles, existed in the colonies even before the beginning of this century. We have records of five established during the decade of 1785-1794, in the following States and in the order named: Pennsylvania, South Carolina, New York, Massachusetts, and Connecticut. This method of aid to agriculture has constantly increased during the nineteenth century, and agricultural societies, the name generally applied to them, have multiplied so that at the present day there are probably few counties in the United States where some form of agricultural society does not exist, while all the leading agricultural industries are represented by State, and, in many cases, by national organization.

Many of these voluntary associations receive State aid, and especially is this true of those organized mainly for the purpose of holding annual fairs. About 1,500 such associations are now in existence, extensively distributed throughout the country, but more especially throughout the North Central and North Atlantic States. Of farmers' clubs, it is sufficient to say their name is legion. Another of these agencies consists of the commissioners of agriculture or boards of agriculture of the different States, and almost every State has some official organization in the interests of agriculture. To these must be added the agricultural colleges and the experiment stations, in which the Federal and State governments co-operate.*

Finally, the most important of the agencies referred to is the Department of Agriculture itself, which began as an insignificant division in the Patent Office, Department of the Interior, in 1839, became a Department under a Commissioner in 1862, and in February, 1889, was erected into an Executive Department under a Secretary, who is a member of the Cabinet.

STATISTICS.

Agricultural Censuses.

Important and extensive collections of statistical information with regard to farms and their products have been made by national and State censuses.

The first statistics of agriculture collected by a United States census were obtained in 1840, within limits much narrower than those adopted in the censuses of 1890 and 1900.

At the present time it is the policy of the Census Office to procure an inventory of farm property and products, with detailed statements for acreage, values, quantities, and numbers of live stock, as far as applicable. It is expected that the national census of this year will procure many facts with regard to the farms of this country, which are now supposed to number about 5,000,000. No other country takes such a thorough, extensive, and detailed census of agriculture as does the United States.

The use of the censuses of agriculture might be the subject of extended discussion, but comparatively little can be said here. Not a day passes that the Department of Agriculture does not need to use census statistics of agriculture in many ways and for many purposes, not only in its own routine work of crop estimates and in the preparation and conduct of statistical investigations, but also in response to numerous letters received from residents of the United States and foreign countries.

Some of the States are required by their constitutions, or by legislative enactments, to take censuses, but not all of them comply with the requirement. The most elaborate State census of agriculture is taken by Massachusetts. Among the other States required to take censuses are Indiana, Iowa, Kansas, Michigan, Oregon, Oklahoma, and Wisconsin.

Useful agricultural statistics are collected and published also by the boards of agriculture of the several States, notably by the States of Texas and Kansas.

Statistics of Development.

The progress of American agriculture up to the present time has by no means been thoroughly discussed in this paper, nor is it possible to do so within the limits of a Yearbook article; hence only a few more topics can be mentioned. First, statistics expressing development will be given.

Farms and Acreage.—The number of farms increased from 1,449,073 in 1850 to 4,564,641 in 1890. During the same time the total farm acreage increased from 293,560,614 to 623,218,619 acres, of which the increase in improved acreage was greater, both absolutely and relatively, than the increase in the unimproved acreage.

Increasing Importance of Medium-Sized Farms.—The average size of farms declined from 203 acres in 1850 to 137 acres in 1890, and it has been established by a thorough statistical analysis that in the more recent years the increase in number of farms has more largely accrued to farms of medium size than to farms of the smaller and larger sizes. Why this should be so is only a matter of conjecture. It may be that the persons who acquire the proprietorship of farms, either as owners or as tenants, have become more able to acquire the possession of medium-sized farms, and so reject or consolidate the smaller farms; it may be also that the larger farms have not been found to be as profitable as medium-sized farms.

The use of machines is an important element in this country's agriculture, and possibly the medium-sized farm as it exists to-day is susceptible of being more economically cultivated and managed than either smaller or larger farms, and among the economic reasons for this the farm machine must be reckoned as highly important. But whatever the explanation may be, the fact remains that the middle-class farmer, according to the tendency disclosed by the census of 1890, is coming more and more to the front among agriculturists.

Farm Real Estate and Machines.—The value of the real estate of farms increased from $3,271,575,426 in 1850 to $13,279,252,649 in 1890. During this period the value of farm implements and machines increased from $151,587,638 to $494,247,467; but these numbers do not adequately represent the increase in the importance of implements and machines, partly because these figures take no account of the vast increase in their efficiency, which has been infinitely greater than the figures express, and in a very large degree because of the much cheaper prices prevailing in 1890.

* No attempt is made here to explain even briefly the work of the agricultural colleges and experiment stations as a factor in the development of agriculture, both agricultural education, during this century, and the work of the agricultural experiment stations being treated at length in other papers in this Yearbook.—ED.

Farm Products.—The censuses have very poorly ascertained the value of farm products, the statements undoubtedly being considerably under the facts. The published statement of the census of 1890 gives the value of farm products as $2,460,107,454, but an estimate made on the production ascertained in the census of 1890 by Mr. J. R. Dodge, former Statistician of the Department of Agriculture, places the value of farm products in the agricultural year covered by that census at about $3,500,000,000.

Farm animals have increased as follows, as shown by national censuses: Horses, from 4,336,719 in 1850 to 14,969,467 in 1890; mules and asses, from 559,331 in 1850 to 2,295,532 in 1890; milch cows, from 6,385,094 in 1850 to 16,511,950 in 1890; oxen and other cattle, from 11,393,813 in 1840 to 34,851,622 in 1890; swine, from 26,301,293 in 1840 to 57,409,583 in 1890; sheep, not including spring lambs, from 19,311,374 in 1840 to 35,935,364 in 1890. The wool clip of the census year of 1890 amounted to 165,449,239 pounds. The value of live stock increased during the period 1850-1890 from $544,180,516 to $2,208,767,573.

Farm dairy products are thus stated in the census of 1890: Entire number of gallons of milk produced on farms, 5,210,125,567; pounds of butter, 1,024,223,468; pounds of cheese, 18,726,818. It must be remembered that the production of butter and cheese on farms has been largely transferred to creameries, whose products are not included in the foregoing figures, but are included in part in the census statistics of manufactures—only in part, however, because it is known that a very large portion of the creameries and their products were omitted from the census statistics of 1890.

Poultry.—In 1890 it was reported that the chickens on farms numbered 258,871,125; other fowls, 26,738,315; and that the eggs produced and sold during the census year were 819,722,916 dozen. The poultry statistics, however, probably fall far short of the facts.

Crop Production.—Coming now to the production of crops, the following extracts are made from the censuses of 1840 and 1890, to which the figures of the Department of Agriculture for 1899 are added:

Cereals.—Production of indian corn, 377,531,875 bushels in 1840; 2,122,327,547 bushels in 1890; 2,078,143,933 bushels in 1899; and the corn acreage increased from 62,368,504 acres in 1880 to 82,108,587 acres in 1899.

The wheat product was 84,823,272 bushels in 1840; 468,373,968 bushels in 1890; 547,303,846 bushels in 1899; and from 1880 to 1899 the wheat acreage increased from 35,430,333 acres to 44,592,516 acres.

The United States produces more wheat than any other country in the world. A comparison may be made for 1898: Crop of the United States, 675,149,000 bushels; France, 371,881,000 bushels; Austria-Hungary, 170,938,000 bushels; Italy, 133,372,000 bushels; Germany, 115,000,000 bushels; United Kingdom, 77,170,000 bushels; Russia in Europe, 404,836,000 bushels; Russia in Asia, 94,000,000 bushels; total Asiatic production, 421,321,000 bushels; total African production 44,439,000 bushels; total South American production, 72,000,000 bushels.

The oat product was in bushels, in 1840, 123,071,341; in 1890, 809,250,666; in 1899, 796,177,713. The oat acreage was 16,144,593 in 1880, and increased to 26,341,380 acres in 1899.

The rye product was 18,645,567 bushels in 1840, 28,421,398 bushels in 1890, and 23,961,741 bushels in 1899, with a decrease of acreage from 1,842,233 acres in 1880 to 1,659,308 acres in 1899.

Cotton.—The cotton crop of 1850 amounted to 2,469,093 bales, and the crop increased decennially up to the census of 1890, and almost without a break annually since that year until the enormous crop of 1898 99, which amounted to 11,189,205 bales of considerably heavier weight than the bales of 1850. The cotton acreage increased from 14,480,019 acres in 1880 to the largest acreage yet attained, in 1898-99, which was 24,967,295. The cotton crop of the United States substantially dominates the world market for cotton, its proportion of the world's crop being from 80 to 85 per cent, and practically having little competition within the lines of its own grades and qualities. The State of Texas alone produces more cotton than any foreign cotton-producing country.

Hay.—The hay production amounted to 10,248,109 tons in 1840; to 66,831,480 tons in 1890, and to 56,655,756 tons in 1899; and the acreage increased from 30,631,054 acres in 1880 to 41,328,462 acres in 1899.

Tobacco.—From 1840 to 1890 the production of tobacco increased from 219,163,319 pounds to 488,256,646 pounds, and the acreage in the latter years was 695,301 acres.

Potatoes.—White potatoes are a crop of extraordinary increase, the bushels in 1850 being 65,797,896; in 1890, 217,546,362, and in 1899, 228,783,232. From 1850 to 1890 the production of sweet potatoes increased from 38,268,148 to 43,950,261 bushels.

Agricultural Exports.

The development of the agriculture of the United States has much more than kept pace with the enormous immigration, increase of population, increase of domestic consumption for food and manufactured products, and for cattle and other domestic animals. It has furnished besides an enormous surplus for export. Only the exports of the principal products can be given briefly:

Wheat.—The wheat export was 4,272 bushels in 1823; 4,155,153 bushels in 1860, and 139,432,815 bushels in 1899. During the same time wheat flour was exported to the amount of 756,702 barrels in 1823, 2,611,596 barrels in 1860, and 18,502,690 barrels in 1899.

Cotton.—The exports of raw cotton amounted to 173,723,270 pounds in 1823, to 1,767,686,338 pounds in 1860, and to 3,773,410,293 pounds in 1899. The more recent product, cottonseed oil, had an export of 50,627,219 gallons in 1899, and the export trade in this product has chiefly grown up since 1889.

Hay and Barley.—The hay export is relatively small, amounting to only 64,916 tons in 1899. The barley export also is comparatively small, amounting to 2,267,400 bushels in 1899, although it reached its maximum amount of 20,030,301 bushels in 1897.

Corn.—The corn export was 749,034 bushels in 1823;

it was 3,314,155 bushels in 1860, and 174,089,094 bushels in 1899. In addition to the unmanufactured corn exports are the exports of corn meal, and these amounted to 791,488 barrels in 1899; but a large portion of the corn product is consumed by domestic animals, the exports of which are mentioned below.

Oats and Rye.—In 1899 the oat export amounted to 30,309,680 bushels, and the oat-meal export was 58,042,505 pounds. In the same year the rye export was 10,140,876 bushels, and the rye-flour export 4,826 barrels.

Animals and Animal Products.—The following are the exports of farm animals in 1899, the figures representing numbers of animals: Cattle, 389,490; hogs, 33,031; horses, 45,778; mules, 6,755; sheep, 143,286. These numbers have grown during the last twenty-five years from almost nothing.

The exports of beef products amounted to 19,053,800 pounds in 1866, not including preserved meats, and the entire quantity of beef products exported in 1899 was 368,666,638 pounds; in the latter year the beef-tallow exports amounted to 107,361,009 pounds. In 1866 the pork products exported amounted to 97,756,169 pounds, and the number had grown to 1,700,380,357 pounds in 1899. In 1899 the mutton exports amounted to 379,110 pounds.

A large item of export has grown up within a few years under the name of oleo oil, and its export in 1899 aggregated 142,390,492 pounds.

The butter and cheese exports have in late years shown a decline, and in 1899 they amounted, respectively, to 20,247,997 and 38,198,753 pounds.

Tobacco.—For many years tobacco has been a large item of export, and its quantity has substantially remained constant for twenty-five years or so. The pounds of leaf tobacco exported in 1899 were 272,421,295, and the value of the manufactured tobacco exported in that year was $5,179,012.

Wool.—The wool export has rarely reached 1,000,000 pounds, although in 1896 it almost equaled 7,000,000 pounds.

The statistics immediately preceding, as well as the others in this paper, express forcibly and comprehensively, although tersely, the agricultural development through which this country has passed up to the present time—a development which has been unparalleled in the history of the world in its rapidity and magnitude.

(To be continued.)

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

American Furniture in Germany.—This consular district offers, in my judgment, a desirable market for American household and kitchen furniture, especially for medium-grade oak chairs—with and without rockers—tables, and possibly bookcases. Rocking-chairs, almost unknown in many parts of Germany, are gradually growing in favor in this locality. A dealer here recently laid in a small and fairly select stock of oak rockers, dining-room chairs, and ordinary office chairs, all of American make. He assures me he is having a fair trade at good prices. As is well known, American desks and other office furniture find an excellent and constantly growing market in Germany. Well-directed efforts would secure even better results in other lines of American furniture.

German furniture is, as a rule, fairly handsome in appearance, but exceedingly expensive. Many of the processes of carving and otherwise decorating sideboards, mantels, chairs, etc., effected in the United States by machinery, are here worked out by hand at greatly increased cost. Much furniture is made under special order. Our manufacturers should, first of all, if they seek to enter and to hold this market, send nothing but well-made, substantial furniture. The German market is no place to sell "shoddy" goods, and certainly not shoddy furniture. The furniture sent "knocked down" should be carefully put together by competent persons. It should be revarnished and put in first-class shape before being placed on the market. The manufacturer should himself insist upon this, or, better still, arrange to have it done by his own employes.

Mannheim being practically at the head of Rhine navigation and, with its immediate suburbs, having a population of about 210,000, offers excellent facilities as a center of distribution for American wares to south and west German points. Ocean barges, loaded directly from steamers at Rotterdam, Amsterdam and other ports, come to Mannheim with vast cargoes of lumber, petroleum, copper, cotton and other merchandise. Wiesbaden, Baden Baden, Karlsruhe, Heidelberg, Strassburg and other nearby points much frequented by Americans should insure a special demand for our furniture.

In this connection may be mentioned barbers' chairs. The native barber chair is cheap and uncomfortable. The head rest is generally wood, without a cushion of any kind. The German barber shaves his customer rapidly, consuming but a few minutes in the entire process. The elaborate American chair, in which the customer is in an almost horizontal position, would not meet with favor here. A neat, comfortable chair, with a plain foot rest and a head rest easily adjusted and comfortable, would, in my judgment, find a ready sale in this part of Germany if properly introduced. They should be handled by a local dealer or agency, well located and thoroughly competent.—H. W. Harris, Consul at Mannheim.

Maltese Trade Information.—During the past few months, there has been a sudden impetus in trade between Malta and the United States. To-day, more American goods may be found on sale here than for a great many years past, and the outlook seems to indicate that a year from now will see an increase over the present favorable conditions to the extent of at least 50 per cent. Up to two years ago, Malta had been for a very long period without direct communication with the United States. The supply of American goods was very limited and arrived here by purchase in England or by transshipment at other ports. The favorable conditions mentioned above may be directly traced to the establishment of a direct line of steamers between New York and Malta. At first, there must have been some loss to the company (Mediterranean and New York Steamship Company). When the line was established, merchants here were inclined to be skeptical as to its permanency; but when it was seen that the steamers were arriving with reasonable regularity, their views changed and inquiries were made for addresses of American merchants. A generation had passed since the days of the fast American clipper ships, and their disappearance resulted in an almost total extinction of trade in our goods. Necessarily, during this interval, many changes occurred; business conditions altered on both sides of the ocean, and when the present direct line was instituted, there was lack of information as to standing and addresses of business houses.

These addresses having been furnished, there is to-day a large correspondence between merchants of Malta and of the United States. Not only this, but my own mail has grown, and I find one of my most important duties is that of answering American seekers of information as to Maltese trade. On an average, it takes thirteen days for a letter to travel from New York to Malta, and a month may be safely estimated from the time the letter is sent before the reply is received. In order to save as much time as possible, I have prepared a list of a few of the prominent concerns, with their respective lines. Many of the firms and individuals mentioned do not at this date deal in our goods, but I believe correspondence with them on the part of our merchants will in most cases result favorably. I have not included in the list many houses here that are dealing with the United States, for the reason that they are well started, and it is perhaps better to confine my efforts to virgin soil.

There are quite a number of establishments here that do an extensive business in bottling mineral waters. Several of them hold contracts for supplying the army and navy canteens. The quantity of this class of goods consumed by this trade alone is surprising. The flavors used, in the case of waters that are flavored, comprise lemon and a very poor quality of fruit. I believe that quite a trade in root beer and sarsaparilla extracts might be secured; they would prove a novelty in this market. In sending price lists and correspondence, our merchants should, however, remember that these goods are put up here at very low prices, and quotations should be governed accordingly. It would not be a bad plan to send samples.

In sending circulars and in correspondence, I would state that the English language may be used. In some instances in the above-mentioned lists I have not given street numbers, for the reason that no numbers are used. All of these concerns are located in the capital city of the islands—Valletta, Malta. In the matter of address, I would say that many of the letters I have received of late have shown lack of information on the part of the writers as to the geographical location of Malta. Some of them have been addressed "Malta, Gibraltar," "Malta, Spain," "Malta, Greece," and even "Malta, Africa." A little study of the map will show that the proper address should be "Valletta, Malta."—John H. Grout, Consul at Valletta.

Prohibition of German Meats by Russia.—A new and important phase of the meat question has lately arisen: Russia has prohibited the importation of German meats. This action seriously affects one of the principal industries of Brunswick (the manufacture of various kinds of sausage), and the chamber of commerce here has addressed a petition to the Department of the Interior at Berlin, calling attention to the commercial treaty with Russia and claiming that the imports from Germany should not be restricted by any kind of prohibition, and that certain products can only be excluded under special circumstances, when hygienic or veterinary police regulations come into question. The petition goes on to say:

"If article 610 of the Russian tariff act wholly forbids the import of German preparations of swine flesh, we look upon this as an evasion of the commercial treaty with Germany. The fear that trichinosis might be introduced through the importation of German sausage is deprived of any foundation by reason of the legal prescriptions and the scientifically executed trichinæ inspection."

The National Zeitung and the Vossiche Zeitung are of the opinion that the prohibition recently issued by the German government against the importation of foreign meats into Germany has given a weapon to Russia and other foreign countries, by which they can ward off the efforts to promote the export of German meats. In regard to the argument that Russia ignores the German inspection for trichinæ, the Brunswick Landeszeitung notes that Russia may appeal to the fact that Germany does not recognize the American meat inspections, although the Americans assert that these are thoroughly trustworthy. It adds:

"Such an argument may be regarded as unassailable as to form, but it is really very weak, for Germany can produce proof that between German and American inspection there is as much difference as between night and day. If the Russians made use of this pretext, which would moreover be interfering in our own affairs, they could be easily set right."

It is unfortunate that the proof referred to is not produced. If it were, there would hardly be room for argument, and the purity of Brunswick sausage would be demonstrated beyond question.—Talbot J. Albert, Consul at Brunswick.

New Spanish Railway.—As illustrating the effort now being made in Spain to meet the prevailing high cost of coal by pushing the development of the native mines, a brief account of the proposed new railway from Saragossa to Utrillas may be of interest, and at the same time assist United States manufacturers who desire to tender bids for the required material.

Utrillas lies about 70 miles south of the city of Saragossa, in the hilly district of the province of Teruel. It has long been known for its collieries, but these, owing to the lack of transportation—which made competition with Welsh coal impossible—have never been properly worked.

The length of the proposed new line is about 77 miles, 40 miles of which will run over smooth ground, offering no difficulty or special expense of construction; 20 miles will be through a somewhat hilly but easy country and the [illegible] rough a difficult region. In the construction of the last 17 miles, there will be required one straight tunnel, not far from Saragossa, 480 yards long (the only one on the line); and three bridges—one near the tunnel, 56 yards in length and 81 feet in height at the deepest point, another of the same dimensions on the border of the provinces of Saragossa and Teruel, and the third, the most important, at Belchite, with a length of 122 yards and a maximum elevation of 130 feet. The bridges will all be of masonry, owing to the proximity of good stone quarries.

With so few engineering difficulties to overcome, the cost of the line will not be great, even in hilly sections, the narrow 1-meter gage (3.28 feet) allowing many tunnels to be dispensed with.

The line throughout is planned as economically as possible, with due regard to perfect construction and the most modern improvements.

The steel rails are to weigh 30 kilogrammes (66.165 pounds) per lineal meter (3.28 feet), laid on wooden sleepers that are already being prepared in the pine forests purchased for that purpose by the company.

The locomotives are to be compound, weighing 40 tons, with an average speed of about 22 miles an hour.

The primary object of the line being the transportation of freight, the rolling stock will be chiefly devoted to that purpose. There are to be ten stations on the line, and it is intended to provide the depot at Saragossa with every facility for rapid loading and unloading.

All communications should be addressed to Mr. Mariano Baselga, Saragossa, Spain.—Maddin Summers, Vice and Deputy Consul-General at Barcelona.

English Trade Unions.—The British Board of Trade has just issued a report on the trade unions of the United Kingdom, an abstract of which will be of especial interest to similar organizations in the United States. The number of unions for which comparative statistics of membership are given for the period 1892 to 1899 is 1,685. Some of these unions were not in existence during the whole of this period, and the number on the list at the end of 1899 was 1,292, compared with 1,218 at the end of 1892. The membership of all the unions at the end of 1899 was 1,802,518, as compared with 1,503,232 at the end of 1892, an increase of 20 per cent in the eight years. During 1899, the total number of trade unions decreased from 1,310 to 1,292. This decline of 18 is due to amalgamation of that number of smaller unions with larger organizations, the number of unions (30) formed during the year being the same as the number dissolved. The total membership, however, of the trade unions rose during the year from 1,649,231 to 1,802,518, an increase of 153,287, or 9 per cent, the greatest proportionate gain in any of the eight years covered by the report. This increase is due to the general rise in the membership of unions of every trade, with the single exception of the unions in the clothing trades, which show a small decrease. The unions which most largely increased their membership during the year were those in the mining and quarrying industries, which showed a gain of 71,084 members, or 20 per cent.

With regard to the sex of members, the returns show that 139 unions included women in their membership, the number being 120,448, or nearly 7 per cent of the total membership of all trade unions and 35 per cent of the membership of the 139 unions which include female members. The bulk of this membership is to be found in the textile trades, which include 109,076, or over 90 per cent of the total number of female trades-unionists. Figures with regard to income, expenditure, etc., of 100 only of the principal unions, with a membership of 1,117,465, show that their funds at the end of the year amounted to £3,282,922 ($15,976,640). The total income was £1,864,006 ($9,060,185). Compared with 1898, the figures show an increase in the funds and total membership, but a decrease in the income and expenditure, the loss in both cases being principally due to the comparative freedom of the year from disputes of any magnitude. The decrease in expenditure in the metal, engineering and shipbuilding group of trades amounted to no less than £168,612 ($917,880); the expenditure in 1899 being £459,147 ($2,234,439), as compared with £627,759 ($3,054,989) in 1898.—S. C. McFarland, Consul at Nottingham.

New Process for the Preparation of Leather.—Under date of Rotterdam, January 8, 1901, Vice-Consul Voorwinden transmits the following for the information of United States tanners:

Mr. P. A. Bloys van Treslong Prins, of 88 Laan Copes, The Hague, called at this consulate a few days ago and showed me some samples of leather ready for saddler's use and seemingly of a very good quality. He stated that it had been prepared by a new process, by means of machinery of which he alone knows the construction, and that by using this system a moist hide can be turned into leather ready for saddler's and shoemaker's use in from two to three days, while by following the usual method of preparation it takes about six months. He also stated that, previous to making application for patent on the machinery, he would like to correspond with American tanners in regard to his process for making leather, with a view to introducing it in the United States.

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

TRADE NOTES AND RECEIPTS.

Liquid Polish.—Mix 100 parts of poppy oil, 750 parts of ether, 100 parts of oil of turpentine and 100 parts of benzine. Rub down the furniture with a little rag charged with the liquid.

To Soften Horn.—It is laid for 10 days into a solution of water, 1 liter; nitric acid, 3 liters; wood vinegar, 2 liters; tannin, 5 kilos; tartar, 2 kilos, and zinc vitriol, 2.5 kilos.—Werkmeister Zeitung.

Protective Coating for Bright Iron Articles.—The medium in question is produced from the following substances: Zinc white, 30 kilos; lampblack, 2 kilos; tallow, 7 kilos; vaseline, 1 kilo; olive oil, 3 kilos; varnish, 1 liter. Boil together one-quarter hour and add ½ liter of benzine and ¼ liter of turpentine, stirring the mass carefully and boiling for some time. The finished paste-like substance can be readily removed with a rag without the use of solvents.—Chemiker Zeitung.

Moldable Mass.—According to the Deutsche Drogisten Zeitung, a plastic mass is produced from wood dust, 17 parts; levigated calcic carbonate, 27 parts; sodium silicate (specific gravity, 1.3 to 1.4), 56 parts. The hardening sets in rapidly, and the mass possesses great tensile and transverse strength and a relatively low specific weight. It can be worked in every manner and dyed and is suitable for the production of toy building blocks and ornamented pieces for children, etc.

Belt Grease for Cotton Belts.—Melt 250 grammes of gum elastic with 250 grammes of oil of turpentine in an iron, well closed crucible at 50 degrees C. (caution!) and mix well with 200 grammes of colophony. After further melting add 200 grammes of yellow wax and stir carefully. On the other hand, melt in 750 grammes of heated train oil 250 grammes of tallow, and to this add with constant stirring the first mixture, when the latter is still warm, and let cool slowly with stirring.—Technisches Centralblatt.

Extraits Simples.—

OPOPONAX ESSENCE.

Musk	7	grammes.
Vanilla pods	55	grammes.
Tonka beans	28	grammes.
Rectified spirits of wine	2½	liters.
Macerate for 28 days and then add:		
Iris extract	560	grammes.
Rose extract	280	grammes.
Jasmine extract	280	grammes.
Cassia extract	280	grammes.
Tuberose extract	280	grammes.
Lemon oil	14	grammes.
Bergamot oil	14	grammes.
Attar of roses	8	grammes.
Patchouli oil	3	grammes.

The last four ingredients are only added after filtration.

PATCHOULI ESSENCE.

Patchouli oil	80	drops.
Attar of roses	[illegible]	[illegible]
Rectified spirit of and cre[illegible]	[illegible]	drops.
[illegible]plements and mac[illegible] wine	½	liter.

Mix.—Journal d. l. Parf. et Savon. Franç.

Baking Powders.—The majority of the baking powders consist of tartaric acid, or tartar and sodium bicarbonate. Here are some receipts: Tartaric acid, 100 grammes and sodium carbonate 100 grammes are finely powdered, each separately, dried perfectly at about 75 deg. C., mixed intimately by grinding, and best preserved in firmly-closed glasses. For use, mix for every kilo of flour two teaspoonfuls of the powder intimately with the dry flour and the necessary quantity of salt, sugar, etc., next adding the water.

Tartaric acid, 1 part; sodium bicarbonate, 1 part; starch, 0.5 part.

Tartaric acid, 3 parts; sodium bicarbonate, 1 part; starch, 0.75 part.

Of the latter baking powder, the required amount for 500 grammes of flour is about 20 grammes for rich cake, and 15 grammes for lean cake.

The substances employed must be dry, each having been previously sifted by itself, so that no coarse pieces are present; the starch is mixed with the sodium bicarbonate before the acid is added. When large quantities are prepared, the mixing is done by machine; smaller quantities are best mixed together in a spacious mortar, and then passed repeatedly through a sieve. Instead of starch, flour may be used, but starch is preferable, because it interferes with the action of the acid on the alkali. Naturally the amount of starch may be increased or lessened, according to the price the powder is to be sold at.—Technische Rundschau, Berlin.

Estimation of Starch.—The aluminium hydrate precipitated from an aluminium salt solution and dried at 100 deg. C. corresponds to the formula $Al(OH)_3$; calcined in a platinum crucible it changes into Al_2O_3. When starch is suspended in water the mixture, mingled with a certain quantity of a titrated alum solution, and next the aluminium precipitated as hydrate with ammonia in excess, the starch is carried along by the aluminium hydroxide. If the precipitate is collected on a filter and washed with as little water as possible until the wash-water contains no more sulphates and this mixture is dried and weighed; the difference between the weight found and the known weight of the aluminium hydroxide corresponding with the used volume of alum solution gives the weight of the starch. Finally, the dried precipitate may be calcined in a platinum crucible, to a constant weight, whereby the aluminium oxide Al_2O_3 + ash of the starch remain as residue. If by this method a considerably larger amount of aluminium oxide should be found than can be computed from the employed amount of the titrated alum solution, the presence of insoluble mineral substances admixed in a considerable quantity would be proved in the starch. The alum solution employed by the author contained 0.060769 gramme of the salt per 1 ccm., corresponding with 0.01 gramme of aluminium hydroxide. According to the author, the results are better than with other estimation methods.—L. Gianturco, in Boll. Chim. Farmac., 1900, 39, 329, through Chemiker Zeitung, Rep.

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